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SITE-SPECIFIC TECHNICAL REPORT FOR BIOSLURPER TESTING AT LANDFILL 3, OPERABLE UNIT 1 AND BUILDING 870, HILL AFB, UTAH

DRAFT

PREPARED FOR:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
(AFCEE/ERT)
8001 ARNOLD DRIVE
BROOKS AFB, TEXAS 78235-5357

AND

HILL AFB, UTAH

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SITE-SPECIFIC TECHNICAL REPORT (A003)

for

BIOSLURPER TESTING AT LANDFILL 3, OPERABLE UNIT 1 AND BUILDING 870, HILL AFB, UTAH

by

A. Leeson, J. Kramer, J.A. Kittel, G Headington, and R. Gillespie

for

Mr. Patrick Haas
U. S. Air Force Center for Environmental Excellence
Technology Transfer Division
(AFCEE/ERT)
Brooks AFB, Texas 78235

January 30, 1996

Battelle
505 King Avenue
Columbus, Ohio 43201-2693

Contract No. F41624-94-C-8012

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This report summarizes the field activities conducted at Hill AFB, for a short-term field pilot test to compare vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery techniques to remove light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at Hill AFB is part of the Bioslurper Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division. The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of the bioslurping technology for (1) recovery of LNAPL from groundwater and the capillary fringe, and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

The main objective of the Bioslurper Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at Hill AFB is one of over 40 similar field tests to be conducted at various locations throughout the United States and its possessions.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial site characterization followed by LNAPL recovery testing. The three LNAPL recovery technologies tested at Hill AFB were skimmer pumping, bioslurping, and drawdown pumping.

Site characterization activities were conducted at Landfill 3, Operable Unit 1 to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. Testing included baildown testing, soil sampling, soil gas permeability testing, and in situ respiration testing.

Following the site characterization activities, the pilot tests for skimmer pumping, bioslurping, and drawdown pumping were conducted at Landfill 3. The LNAPL recovery testing was conducted in the following sequence: 48 hours in the skimmer configuration, approximately 92 hours in the bioslurper configuration, an additional 24 hours in the skimmer configuration, and 47 hours in the drawdown configuration. Measurements of extracted soil gas composition, LNAPL thickness, and

groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

Skimmer and drawdown pumping were not as effective as bioslurping at recovering LNAPL at this site. Free product recovery rates were lower on average during skimmer and drawdown pumping, with average LNAPL recovery rates of 0.80 gallons/day during the skimmer pump test and 0.50 gallons/day during the drawdown pump test. In contrast, LNAPL recovery rates during bioslurping initially were approximately 7.5 gallons/day and stabilized at approximately 1.5 gallons/day after the first day.

Groundwater recovery rates during the bioslurper pump test were high in comparison to rates during the skimmer pump tests, but were comparable to recovery rates during the drawdown pump test. On average, groundwater was extracted at rates of 260 gallons/day during skimming, 1,500 gallons/day during bioslurping, and 2,400 gallons/day during drawdown pumping.

Soil gas concentrations were measured at monitoring points during the bioslurper pump test to determine whether the vadose zone was being oxygenated. Oxygen concentrations changed little until the end of the bioslurper pump test. At this time, oxygen concentrations increased slightly at depths of 16 and 24 ft at all distances from the bioslurper well. Over time, it is likely that the area would become well oxygenated. These results correlate with the radius of influence of 80 ft determined during the soil gas permeability test.

Implementation of bioslurping at Landfill 3 probably would facilitate enhanced recovery of LNAPL from the water table and simultaneous in situ biodegradation of hydrocarbons in the vadose zone via bioventing. Bioslurping will result in extraction of significant quantities of groundwater; however, if disposal at the Industrial Wastewater Treatment Plant is permissible, this will not impact the economic viability of bioslurping.

A baildown test and short-term bioslurper pump test were conducted at Building 870. During the baildown test, free-product levels did not recover to initial levels by the end of the 26-hour test period. During the short-term bioslurper pump test, only minimal quantities of free product were recovered, with a total volume of 0.2 gallons collected at an average rate of 0.11 gallons/day. In contrast, large volumes of groundwater were recovered, with a total volume of 2,033 gallons collected at an average rate of 1,100 gallons/day. These results indicated that the Building 870 site was not suitable for bioslurping probably due to the small quantities of free product.

DRAFT SITE-SPECIFIC TECHNICAL REPORT (A003)

for

BIOSLURPER TESTING AT LANDFILL 3, OPERABLE UNIT 1 AND BUILDING 870, HILL AFB, UTAH

January 30, 1996

1.0 INTRODUCTION

This report describes activities performed and data collected during a field test at Hill Air Force Base (AFB), Utah, to compare vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery technologies for removal of light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at Hill AFB is part of the Bioslurper Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division. The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of the bioslurping technology for (1) recovery of LNAPL from groundwater and the capillary fringe and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

1.1 Objectives

The main objective of the Bioslurper Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at Hill AFB is one of over 40 similar field tests to be conducted at various locations throughout the United States and its possessions. Aspects of the testing program that apply to all sites are described in the *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). Test provisions specific to activities at Hill AFB were described in the Site-Specific Test Plan provided in Appendix A.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping

technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial site characterization followed by LNAPL recovery testing. The three LNAPL recovery technologies tested at Hill AFB were skimmer pumping, bioslurping, and drawdown pumping. The specific test objectives, methods, and results for the Hill AFB test program are discussed in the following sections.

1.2 Testing Approach

Site characterization activities were conducted at Landfill 3, Operable Unit 1 (OU1) to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. Testing included baildown testing to evaluate the mobility of LNAPL, soil sampling to determine physical/chemical site characteristics, soil gas permeability testing to determine the radius of influence, and in situ respiration testing to evaluate site microbial activity.

Following the site characterization activities, the pilot tests for skimmer pumping, bioslurping, and drawdown pumping were conducted at Landfill 3. The LNAPL recovery testing was conducted in the following sequence: 48 hours in the skimmer configuration, approximately 92 hours in the bioslurper configuration, an additional 24 hours in the skimmer configuration, and 47 hours in the drawdown configuration. Measurements of extracted soil gas composition, LNAPL thickness, and groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

A baildown test and short-term bioslurping pump test were conducted at Building 870. Little free product was recovered; therefore, the full scope of pilot tests was not conducted. Results from the baildown test and bioslurper pump test at Building 870 are presented in Section 6.0.

2.0 LANDFILL 3, OU1 SITE DESCRIPTION

Operable Unit 1 is located near the northeast boundary of Hill AFB and contains Landfills 3 and 4, Chemical Disposal Pits (CDPs) 1 and 2, the Waste Phenol Pit, and the Base golf course (Figure 1). Site activities for this study were conducted at Landfill 3. Landfill 3 was operated as a general refuse landfill from 1947 through 1967. Materials dumped and burned at Landfill 3 included

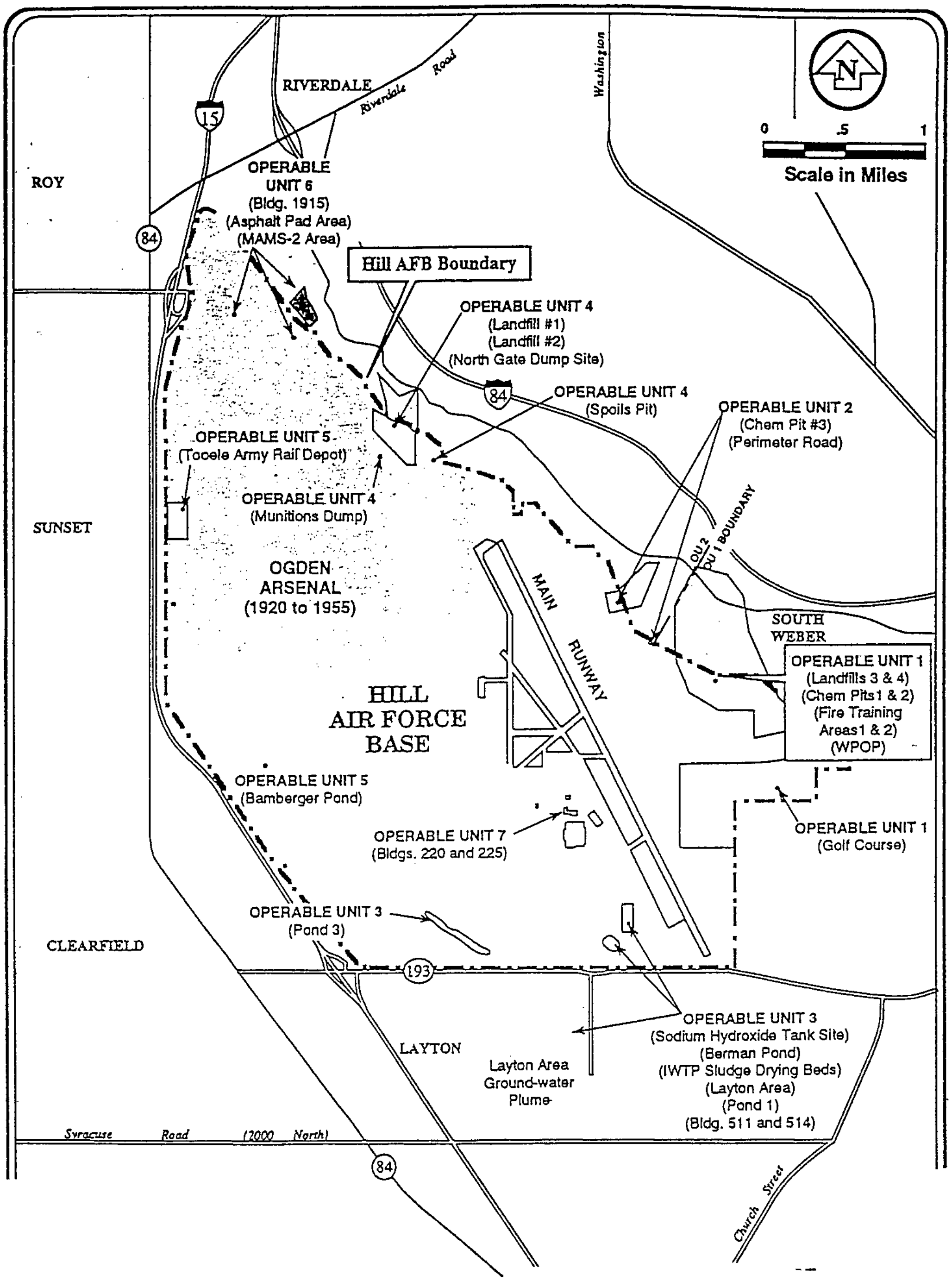


Figure 1. Location of Operable Units, Including Site OU1, at Hill AFB, UT

industrial sludge, waste solvents, and residues from solvent cleaning operations. In 1993, monitoring well U1-101 produced approximately 7 gallons of fuel in a 24-hour extraction period, while monitoring well U1-069 produced negligible amounts (Battelle unpublished data). Monitoring well locations and associated free-product thicknesses measured in January 1994 at Landfill 3 and CDP 1 are shown in Figure 2. Relevant data for monitoring wells U1-101 and U1-069, including well construction data and site geology, are presented in the Site-Specific Test Plan provided in Appendix A.

3.0 BIOSLURPER SHORT-TERM PILOT TEST METHODS AT LANDFILL 3, OU1

This section documents the initial conditions at the test site and describes the test equipment and methods used for the short-term pilot test at Hill AFB.

3.1 Initial LNAPL/Groundwater Measurements and Baildown Testing

Monitoring well U1-101 was evaluated for use in the bioslurper pilot testing. Initial depths to LNAPL and to groundwater were measured using an oil/water interface probe (ORS Model #1068013). LNAPL was removed from the well with a Teflon™ bailer until the LNAPL thickness could no longer be reduced. The rate of increase in the thickness of the floating LNAPL layer was monitored for approximately 18 hours using the oil/water interface probe.

3.2 Well Construction Details

Existing monitoring well U1-101 was selected for use in the bioslurper pilot testing. The well is constructed of 2-inch-diameter, schedule 40 polyvinyl chloride (PVC) with a total depth of 33.5 ft and 10 ft of screen. A schematic diagram illustrating well construction details is provided in Figure 3.

An additional well was installed approximately 20 ft north/northwest of monitoring well U1-101 to monitor changes in depths to free product and groundwater during pump tests. The well was constructed of 2-inch-diameter PVC with a total depth of 33 ft and 10 ft of screen. The well was labeled Batt Well.

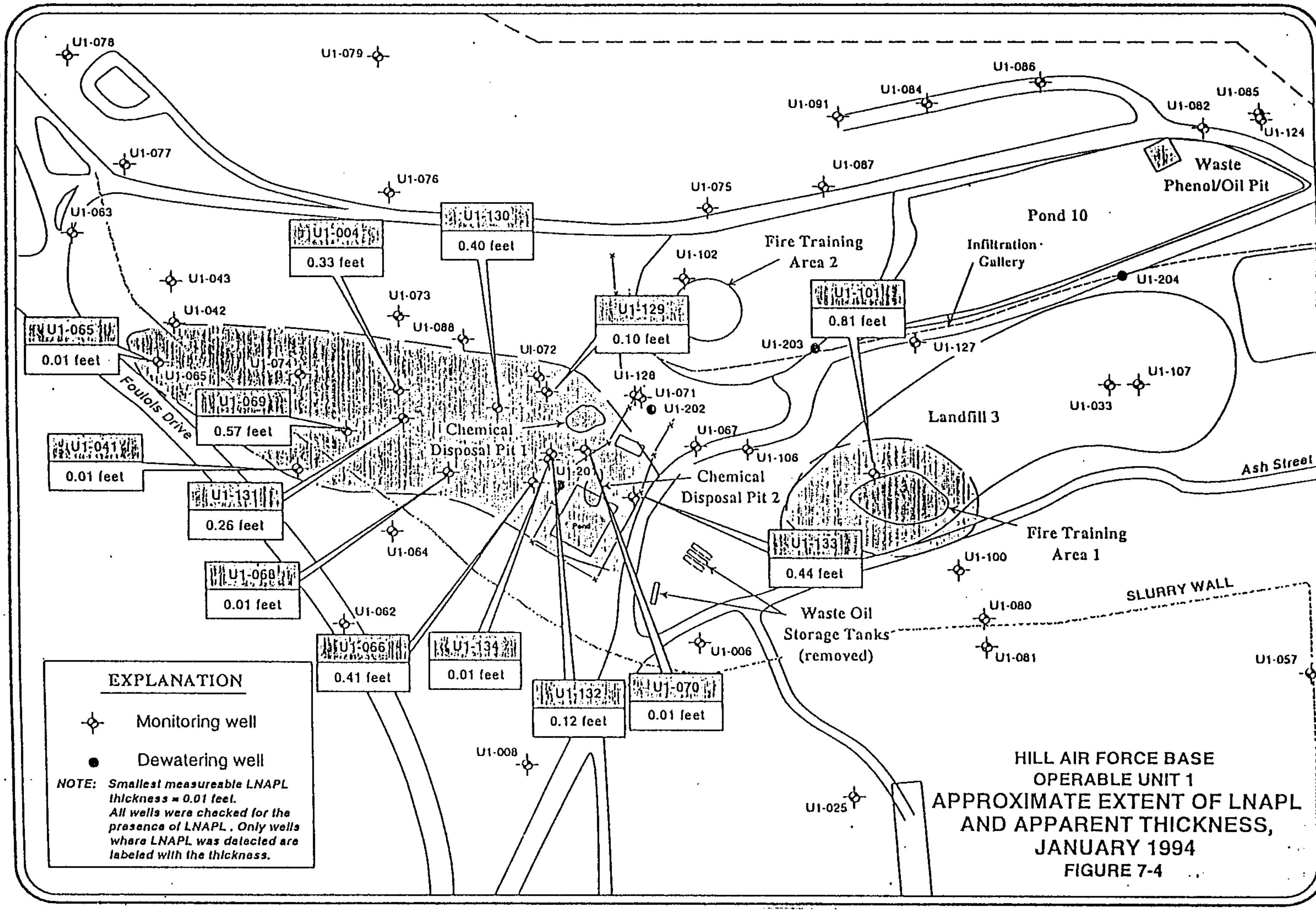


Figure 2. Monitoring Well Locations and Free-Product Thicknesses (1994) at Landfill 3 and CDP 1, OU1, Hill AFB, UT

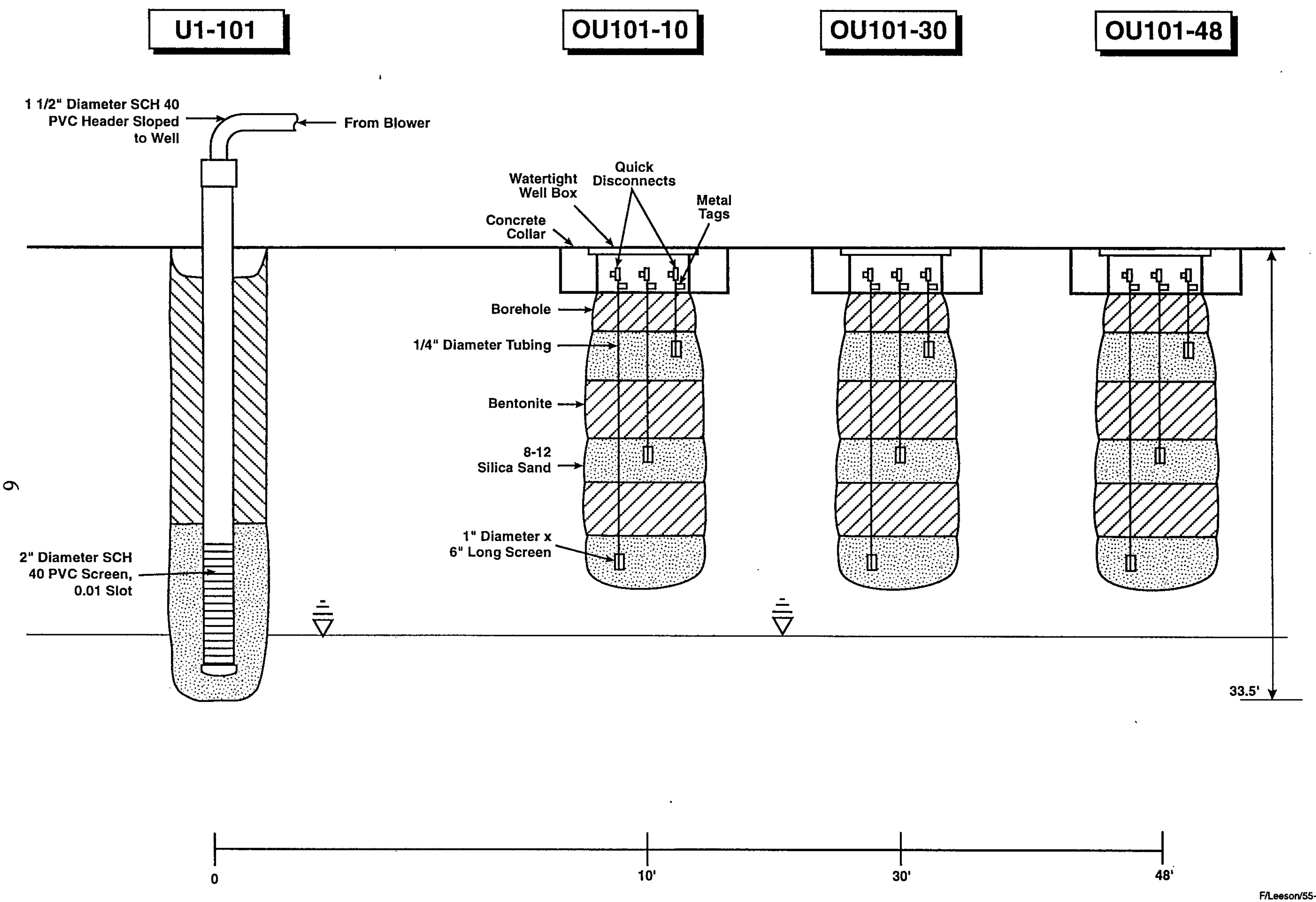


Figure 3. Schematic Diagram Illustrating Construction Details of the Bioslurper Well and Soil Gas Monitoring Points at Landfill 3, OU1, Hill AFB, UT

3.3 Soil Gas Monitoring Point Construction Detail

Three soil gas monitoring points were already in existence in the area of monitoring well U1-101; therefore, no additional soil gas monitoring points were installed. The soil gas monitoring points were located 10, 30, and 48 ft from U1-101 and were identified by Battelle as OU101-10, OU101-30, and OU101-48, respectively. Precise construction details of the soil gas monitoring points are not know. General construction details are illustrated in Figure 3. Screened intervals for all monitoring point were located at depths of 8.0, 16, and 24 ft. Thermocouples were not installed with these monitoring points.

After installation of the monitoring points, initial soil gas measurements were taken with a GasTechtor portable O_2/CO_2 meter and a GasTech Trace-Techtor portable hydrocarbon meter. Oxygen limitation was observed at all depths, with oxygen concentrations ranging from 0 to 0.5% and elevated levels of carbon dioxide and total petroleum hydrocarbons (TPH) (Table 1).

Table 1. Initial Soil Gas Compositions at Landfill 3, OU1, Hill AFB, UT

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
OU101-10	8.0	0.0	11	500
	16	0.25	10	360
	24	0.0	11	500
OU101-30	8.0	0.0	10	230
	16	0.50	11	240
	24	0.0	11	320
OU101-48	8.0	0.0	12	450
	16	0.0	13	250
	24	0.0	12	720

3.4 Soil Sampling and Analysis

Four soil samples were collected during installation of the Batt Well. The soil samples were collected in brass sleeves driven down the center of the hollow-stem auger used to drill the monitoring well. The samples were labeled as follows: HAFB-BW-22.0′-22.5′, HAFB-BW-25.5′-26.0′, HAFB-BW-23.0′-24.0′, and HAFB-BW-25.0′-25.5′. The samples were placed in insulated coolers, chain-of-custody records and shipping papers were completed, and the samples were sent to Alpha Analytical, Inc., in Sparks, Nevada by overnight express. Samples HAFB-BW-22.0′-22.5′ and HAFB-BW-25.5′-26.0′ were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX) and TPH. Samples HAFB-BW-23.0′-24.0′ and HAFB-BW-25.0′-25.5′ were composited and analyzed for bulk density, moisture content, particle size, and porosity. Laboratory analytical reports for all samples are provided in Appendix B.

3.5 LNAPL Recovery Testing

3.5.1 System Setup

The bioslurping pilot test system is a trailer-mounted mobile unit. The vacuum pump (Atlantic Fluidics Model A100, 7.5-hp liquid ring pump), oil/water separator, and required support equipment were carried to the test location on a trailer. The trailer was located near monitoring well U1-101, the well cap was removed, a coupling and tee were attached to the top of the well, and the slurper tube was lowered into the well. The slurper tube was attached to the vacuum pump. Different configurations of the tee and the placement depth of the slurper tube allow for simulation of skimmer pumping, operation in the bioslurping configuration, or simulation of drawdown pumping as described in Sections 3.5.2, 3.5.3, and 3.5.5, respectively.

Vapor emissions were discharged directly to the atmosphere for these short-term tests, since the mass of BTEX and TPH emitted were low. After treatment through the oil/water separator, groundwater was transferred to a Baker tank where it was stored until disposal at the Base Industrial Wastewater Treatment Plant.

A brief system startup test was performed prior to LNAPL recovery testing to ensure that all system components were working properly. The system checklist is provided in Appendix C. All

site data and field testing information were recorded in a field notebook and then transcribed onto pilot test data sheets provided in Appendix D.

3.5.2 Initial Skimmer Pump Test

Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set at the LNAPL/groundwater interface with the wellhead open to the atmosphere via a PVC connecting tee (Figure 4). The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on October 28, 1995, to begin the skimmer pump test. The test was operated continuously for approximately 48 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the skimmer pump test. Test data sheets are provided in Appendix D.

3.5.3 Bioslurper Pump Test

Upon completion of the skimmer pump test, preparations were made to begin the bioslurper pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set at the LNAPL/groundwater interface, as in the skimmer pump test. However, in contrast to the skimmer pump test, the PVC connecting tee was removed, sealing the wellhead and allowing the pump to establish a vacuum in the well (Figure 5). A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on October 30, 1995, to begin the bioslurper pump test. The test was initiated approximately 3 hours after the skimmer pump test and was operated continuously for approximately 92 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. Test data sheets are provided in Appendix D.

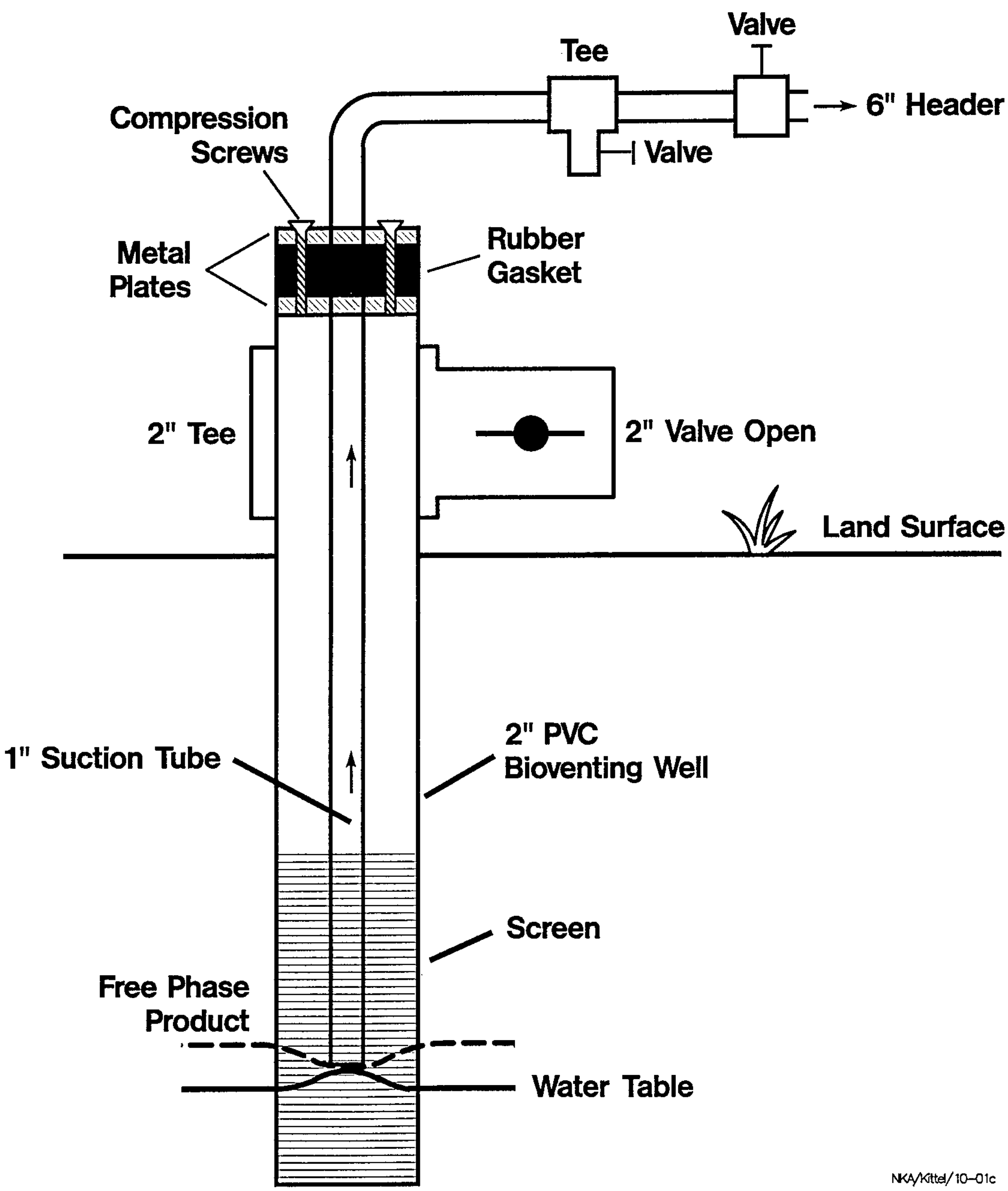


Figure 4. Slurper Tube Placement and Valve Position for the Skimmer Pump Test

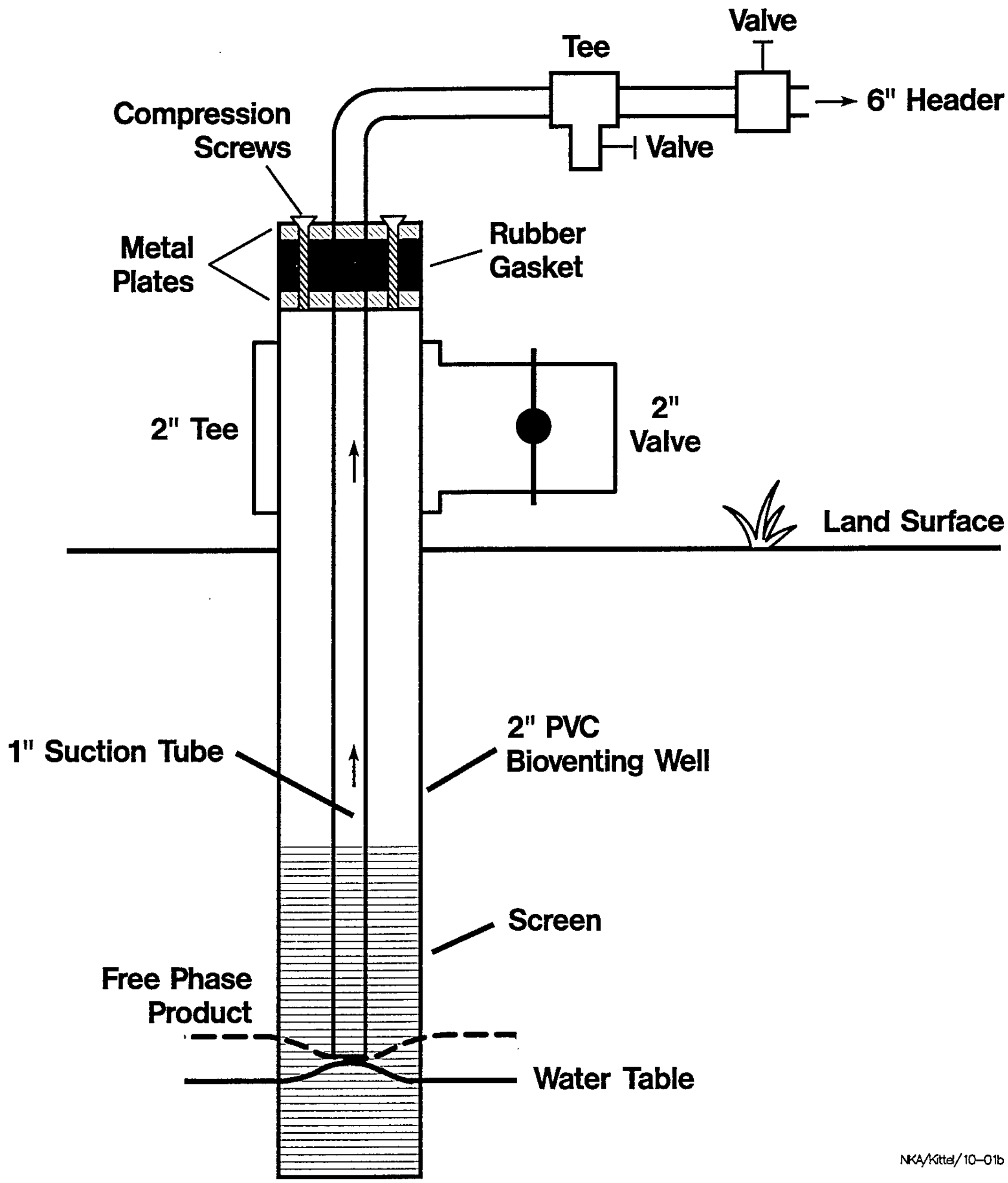


Figure 5. Slurper Tube Placement and Valve Position for the Bioslurper Pump Test

3.5.4 Second Skimmer Pump Test

Upon completion of the bioslurper pump test, preparations were made to begin the second skimmer pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. The valve and slurper tube configuration were identical to that used for the initial skimmer pump test. The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on November 3, 1995, to begin the second skimmer pump test. The test was initiated approximately one hour after the bioslurper pump test and was operated continuously for 24 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. Test data sheets are provided in Appendix D.

3.5.5 Drawdown Pump Test

Upon completion of the second skimmer pump test, preparations were made to begin the drawdown pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set so that the tip was 12 inches below the oil/water interface with the PVC connecting tee open to the atmosphere (Figure 6). The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on November 4, 1995, to begin the drawdown pump test. The test was initiated approximately 15 minutes after the second skimmer pump test and was operated continuously for 47 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the drawdown pump test. Test data sheets are provided in Appendix D.

3.5.6 Off-Gas Sampling and Analysis

Soil gas samples were collected from the bioslurper off-gas during the bioslurper pump test. Samples were collected in Summa™ canisters approximately 2 and 75 hours after test initiation and were labeled HAFB-OGS-STK1 and HAFB-OGS-STK2, respectively. The samples were sent under

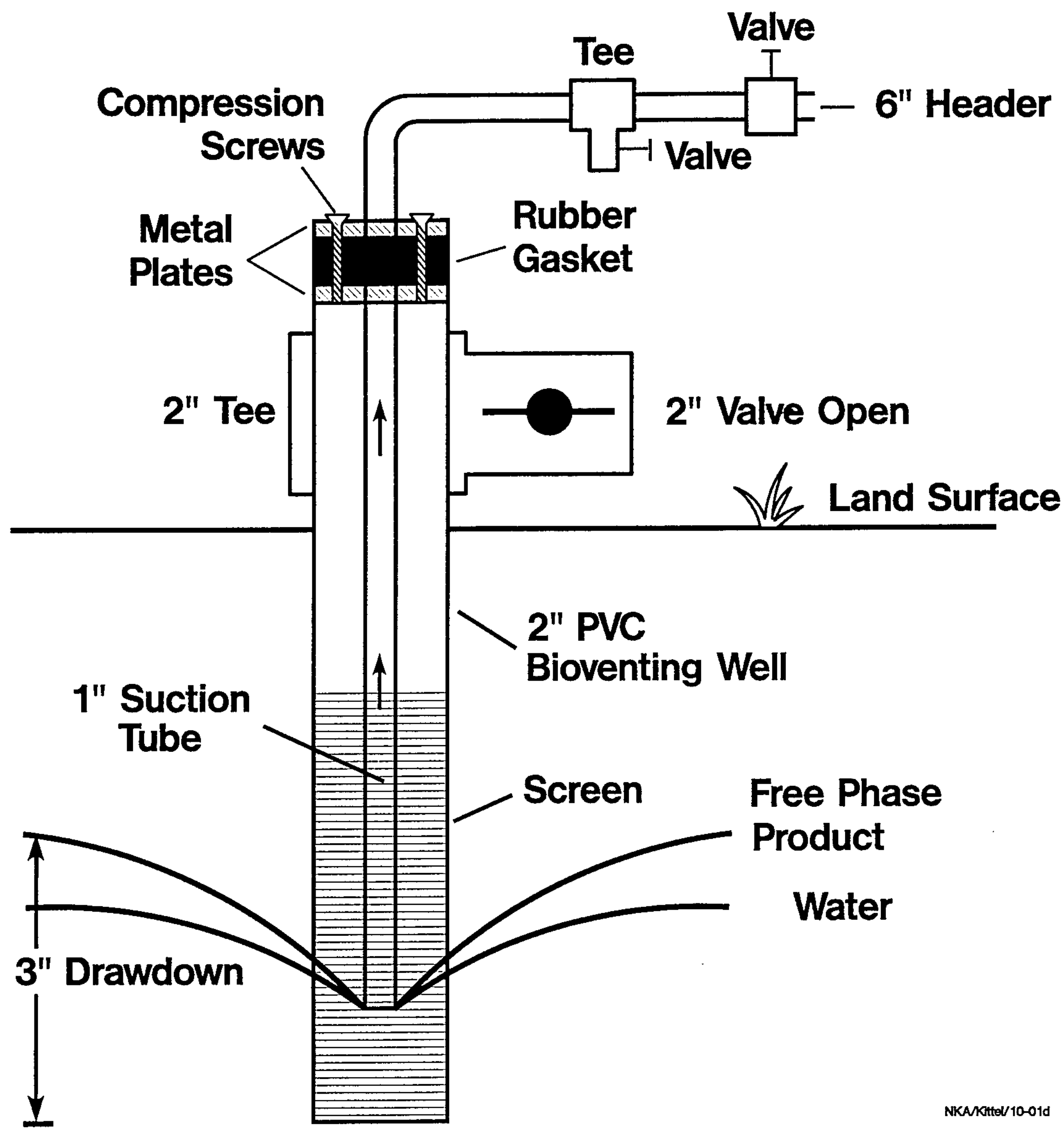


Figure 6. Slurper Tube Placement and Valve Position for the Drawdown Pump Test

chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analyses of BTEX and TPH.

3.5.7 Groundwater Sampling and Analysis

Two groundwater samples were collected during the bioslurper pump test. One sample was collected from the outlet of the oil/water separator and was labeled HAFB-OWS-1. The other sample was collected from the bottom of the Baker tank and was labeled HAFB-Baker-1. Samples were collected in 40-mL septa vials containing HCl preservative. Samples were checked to ensure no headspace was present and were then shipped on ice and sent under chain of custody to Alpha Analytical, Inc., in Sparks, Nevada for analyses of BTEX and TPH.

3.6 Soil Gas Permeability Testing

The soil gas permeability test data were collected during the bioslurper pump test. Before a vacuum was established in the extraction well, the initial soil gas pressures at the three installed monitoring points were recorded. The start of the bioslurper pump test created a steep pressure drop in the extraction well which was the starting point for the soil gas permeability testing. Soil gas pressures were measured at each of the three monitoring points at all depths to track the rate of outward propagation of the pressure drop in the extraction well. Soil gas pressure data were collected frequently during the first 20 minutes of the test. The soil gas pressures were recorded 40 minutes into the bioslurper pump test at which time they leveled off. Pressures were used to determine the radius of influence in the vadose zone. Test data are provided in Appendix E.

3.7 In Situ Respiration Testing

Air containing approximately 2% helium was injected into four monitoring points for approximately 24 hours beginning on November 3, 1995. The setup for the in situ respiration test is described in the *Test Plan and Technical Protocol a Field Treatability Test for Bioventing* (Hinchee et al., 1992). A ½-hp diaphragm pump was used for air and helium injection. Air and helium were injected through the following monitoring points at the depths indicated: OU101-10-24.0′, OU101-10-8.0′, OU101-30-8.0′, and OU101-48-8.0′. After the air/helium injection was terminated, soil gas

concentrations of oxygen, carbon dioxide, TPH, and helium were monitored periodically. The respiration test was terminated on November 5, 1995. Oxygen utilization and biodegradation rates were calculated as described in Hinchee et al. (1992). Raw data for these tests are presented in Appendix F.

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. Helium loss over time is attributable to either diffusion through the soil or leakage. A rapid drop in helium concentration usually indicates leakage. A gradual loss of helium along with a first-order curve generally indicates diffusion. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium diffuses approximately 2.8 times faster than oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. As a general rule, we have found that if helium concentrations at test completion are at least 50 to 60% of the initial levels, measured oxygen uptake rates are representative. Greater helium loss indicates a problem, and oxygen utilization rates are not considered representative.

4.0 RESULTS AT LANDFILL 3, OU1

This section documents the results of the site characterization, the comparative LNAPL recovery pump test, and other supporting tests conducted at Hill AFB.

4.1 Baildown Test Results

Results from the baildown test in monitoring well U1-101 are presented in Table 2. A total volume of 370 mL (0.098 gallons) was removed by hand bailing from monitoring well U1-101. The LNAPL thickness recovered to approximately initial levels by the end of the 18-hour test period. These results indicated that monitoring well U1-101 was suitable for bioslurper field testing.

4.2 Soil Sample Analyses

Table 3 shows the BTEX and TPH concentrations measured in soil samples collected at Landfill 3, OU1. TPH concentrations were relatively high, with an average TPH concentration of

Table 2. Results of Baildown Testing in Monitoring Well U1-101

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
Initial Reading 10/27/95-1550	29.97	28.37	0.60
10/27/95-1600	28.49	28.44	0.05
10/27/95-1617	28.61	28.43	0.18
10/27/95-1633	28.68	28.43	0.25
10/27/95-1648	28.69	28.42	0.27
10/27/95-1705	28.70	28.43	0.27
10/27/95-1720	28.71	28.42	0.29
10/27/95-1735	28.73	28.42	0.31
10/27/95-1750	28.74	28.42	0.32
10/27/95-1805	28.76	28.42	0.34
10/28/95-0956	28.95	28.39	0.56

Table 3. BTEX and TPH Concentrations in Soil Samples from Landfill 3, OU1, Hill AFB, UT

Parameter	Concentration (mg/kg)	
	HAFB-BW-22.0′-22.5′	HAFB-BW-25.5′-26.0′
TPH[1]	1,800	3,500
Benzene	<1.0	<1.0
Toluene	<1.0	<1.0
Ethylbenzene	<1.0	<1.0
Xylenes	<1.0	<1.0

1 Components are primarily in the range of jet fuel, kerosene, and diesel #1.

2,650 mg/kg. BTEX concentrations were below the detection limit of 1.0 mg/kg in both samples. The results of the physical characterization of the soils are presented in Table 4.

4.3 LNAPL Pump Test Results

4.3.1 Initial Skimmer Pump Test Results

The LNAPL thickness prior to the initial skimmer pump test was 0.56 ft (Table 5). A total of 1.64 gallons of LNAPL was recovered during this test, with an average recovery rate of 0.8 gallons/day (Table 6). A total of 255 gallons of groundwater was extracted with an average extraction rate of 126 gallons/day (Table 6). Results of LNAPL recovery versus time are shown in Figure 7.

4.3.2 Bioslurper Pump Test Results

LNAPL recovery rates increased significantly during the bioslurper pump test (Figure 7). The increase in recovery rate indicates that LNAPL was mobilized to the extraction well under vacuum-enhanced conditions. A total of 12.1 gallons of LNAPL and 5,575 gallons of groundwater was extracted during the bioslurper pump test, with daily average recovery rates of 3.2 gallons/day for LNAPL and 1,456 gallons/day for groundwater (Table 6). The LNAPL recovery rate versus time is shown in Figure 8. The vacuum-exerted wellhead pressure on monitoring well U1-101 was kept relatively constant throughout the bioslurper pump test at approximately 0.09 inches of mercury.

Soil gas concentrations were measured at monitoring points during the bioslurper pump test to determine whether the vadose zone was being oxygenated. Oxygen concentrations changed little until the end of the bioslurper pump test (Table 7). At this time, oxygen concentrations increased slightly at depths of 16 and 24 ft at all distances from the bioslurper well. Over time, it is likely that the area would become well oxygenated. These results correlate with the radius of influence as described in Section 4.5.1.

4.3.3 Second Skimmer Pump Test

Totals of 0.6 gallons of LNAPL and 404 gallons of groundwater were recovered during the second skimmer pump test, with daily average recovery rates of 0.6 gallons/day for LNAPL and 404

Table 4. Physical Characterization of Soil from Landfill 3, OU1, Hill AFB, UT

Parameter		Sample	
		HAFB-BW-23.0′-24.0′	HAFB-BW-25.0′-25.5′
Moisture Content (%)		3.8	4.8
Porosity (%)		58.1	58.8
Specific Gravity (g/cm^3)		1.11	1.09
Particle Size	Gravel (%)	0	0
	Sand (%)	58.6	63.1
	Silt (%)	25.6	18.3
	Clay (%)	15.8	18.6

Table 5. Depths to Groundwater and LNAPL Prior to Each Pump Test

Test	Test Start Date	Depth to LNAPL (ft)	Depth to Groundwater (ft)	LNAPL Thickness (ft)
Initial Skimmer Pump Test	10/28/95	28.39	28.95	0.56
Bioslurper Pump Test	10/30/95	28.735	28.79	0.055
Second Skimmer Pump Test	11/3/95	28.82	28.825	0.0050
Drawdown Test	11/4/95	29.18	29.20	0.020

Table 6. Pump Test Results at Landfill 3, OU1, Hill AFB, UT

Recovery Rate (gal/day)	Initial Skimmer Pump Test		Bioslurper Pump Test		Second Skimmer Pump Test		Drawdown Pump Test	
	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater
Day 1	0	140	7.5	1,200	0.60	400	0.3	2,700
Day 2	1.6	120	1.7	800	NA	NA	0.7	2,100
Day 3	NA	NA	1.4	1,300	NA	NA	NA	NA
Day 4	NA	NA	1.5	2,200	NA	NA	NA	NA
Average	0.80	130	3.2	1,500	0.60	400	0.50	2,400
Total Recovery (gal)	1.6	260	12	5,600	0.60	400	1.0	4,700

NA = Not applicable.

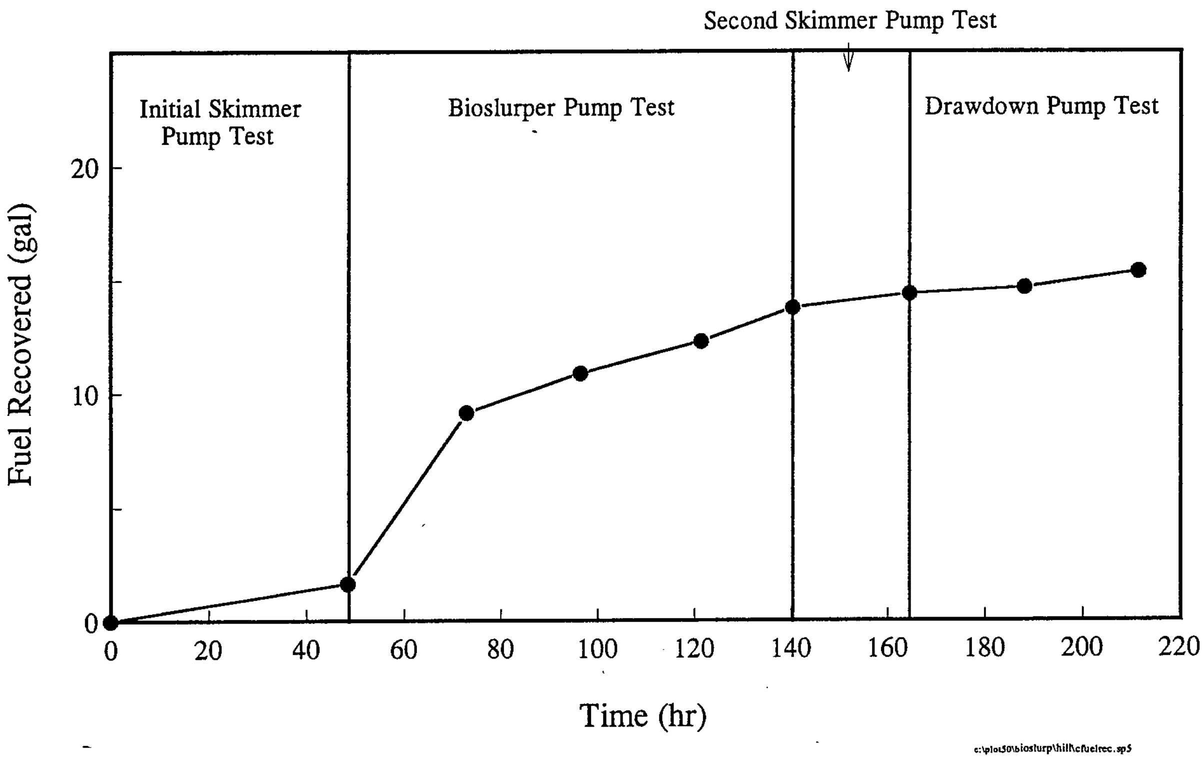


Figure 7. LNAPL Recovery Versus Time During Each Pump Test

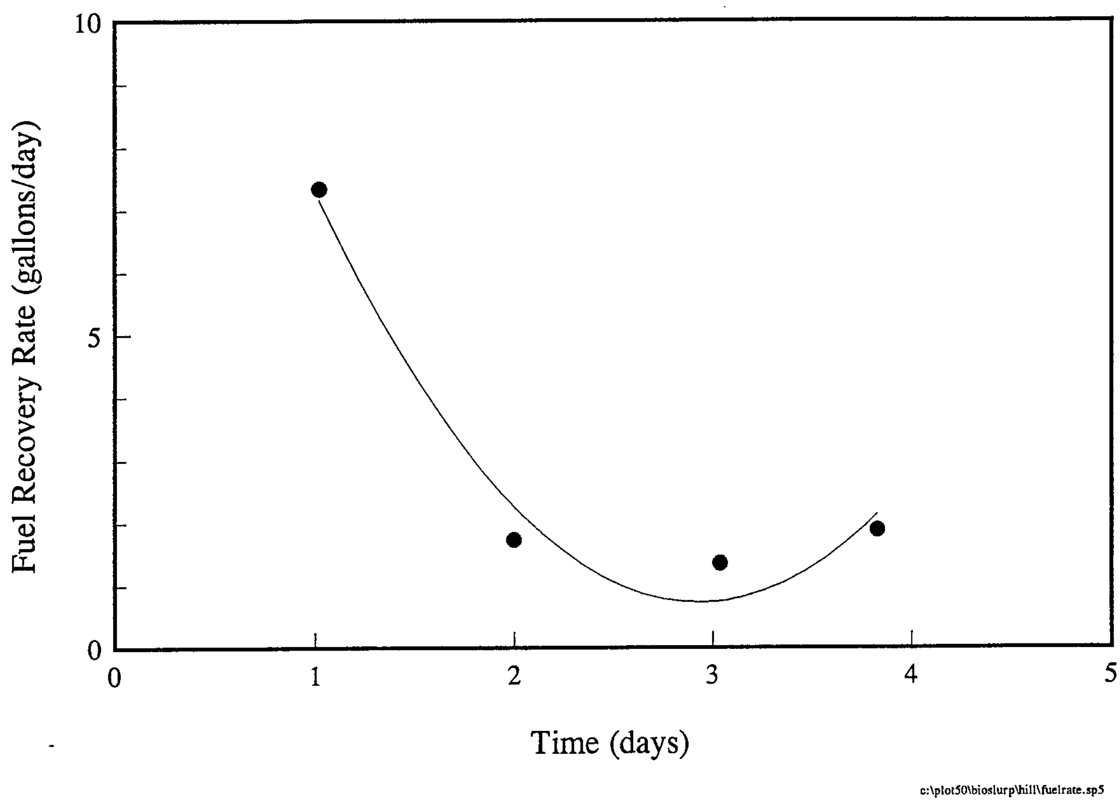


Figure 8. LNAPL Recovery Rate Versus Time During The Bioslurper Pump Test

Table 7. **Oxygen Concentrations During the Bioslurper Pump Test at Landfill 3, OU1, Hill AFB, UT**

Monitoring Point	Oxygen Concentrations (%) Versus Time (hours)			
	0	**27**	**45**	**116**
OU101-10-8′	0.0	0.0	0.0	0.0
OU101-10-16′	0.25	0.0	0.0	0.0
OU101-10-24′	0.0	0.0	0.0	1.0
OU101-30-8′	0.0	0.0	0.0	0.0
OU101-30-16′	0.50	0.0	0.0	3.0
OU101-30-24′	0.0	0.0	0.0	4.2
OU101-48-8′	0.0	0.0	0.0	0.0
OU101-48-16′	0.0	0.0	0.80	6.5
OU101-48-24′	0.0	0.0	0.80	18

[1] One hour after bioslurper pump shut off.

gallons/day for groundwater (Table 6). These results demonstrate that operation of the bioslurper system in the skimmer mode was not as effective a means of free-product recovery as the bioslurper system at this site.

4.3.4 Drawdown Pump Test

Totals of 1.0 gallon of LNAPL and 4,748 gallons of groundwater were recovered during the drawdown pump test, with daily average recovery rates of 0.50 gallons/day for LNAPL and 2,400 gallons/day for groundwater (Table 6). These results demonstrate that operation of the bioslurper system in the drawdown mode was not as effective a means of free-product recovery as the bioslurper system at this site.

4.4 Extracted Groundwater and Off-Gas Analyses

During the bioslurper pump test, groundwater samples were collected from the oil/water separator and from the Baker tank used for storage prior to disposal. BTEX concentrations were less than 0.10 mg/L, while TPH concentrations ranged from 7.4 mg/L in the Baker tank up to 180 mg/L in the oil/water separator (Table 8).

Off-gas samples from the bioslurper system also were collected during the bioslurper pump test. The results from the off-gas analyses are presented in Table 9. Given a vapor discharge rate of 32 scfm and using an average concentration of 4,900 ppmv TPH, approximately 92 lb/day of TPH was emitted to the air during the bioslurper pump test. Benzene emissions were approximately 0.045 lb/day.

4.5 Bioventing Analyses

4.5.1 Soil Gas Permeability and Radius of Influence

The radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the extraction well. The radius of influence is then defined as the distance from the extraction well where 0.1 inch of H_2O can be measured. Based on this definition, the radius of influence at this site is approximately 80 ft (Figure 9).

4.5.2 In Situ Respiration Test Results

Results from the in situ respiration test are presented in Table 12. Oxygen depletion was relatively rapid, with oxygen utilization rates ranging from 0.29 to 0.72 $\%O_2$/hr. Biodegradation rates ranged from 4.8 to 12 mg/kg-day. The helium concentration was steady, indicating that leakage and diffusion were insignificant.

Table 8. BTEX and TPH Concentrations in Extracted Groundwater During the Bioslurper Pump Test at Landfill 3, OU1, Hill AFB, UT

Parameter	Concentration (mg/L)	
	HAFB-OWS-1	HAFB-Baker-1
TPH[1]	180	7.4
Benzene	<0.0050	0.0017
Toluene	<0.0050	0.00057
Ethylbenzene	<0.0050	0.0019
Total Xylenes	0.038	0.015

[1] Components are in the range of jet fuel, diesel, light oil, and motor oil.

Table 9. BTEX and TPH Concentrations in Off-Gas During the Bioslurper Pump Test at Landfill 3, OU1, Hill AFB, UT

Parameter	Concentration (ppmv)	
	HAFB-OGS-STK1	HAFB-OGS-STK2
TPH as jet fuel	6,000	3,800
Benzene	5.2	4.3
Toluene	4.4	3.2
Ethylbenzene	7.0	3.6
Xylenes	20M	7.9M

M = Reported value may be biased due to apparent matrix interferences.

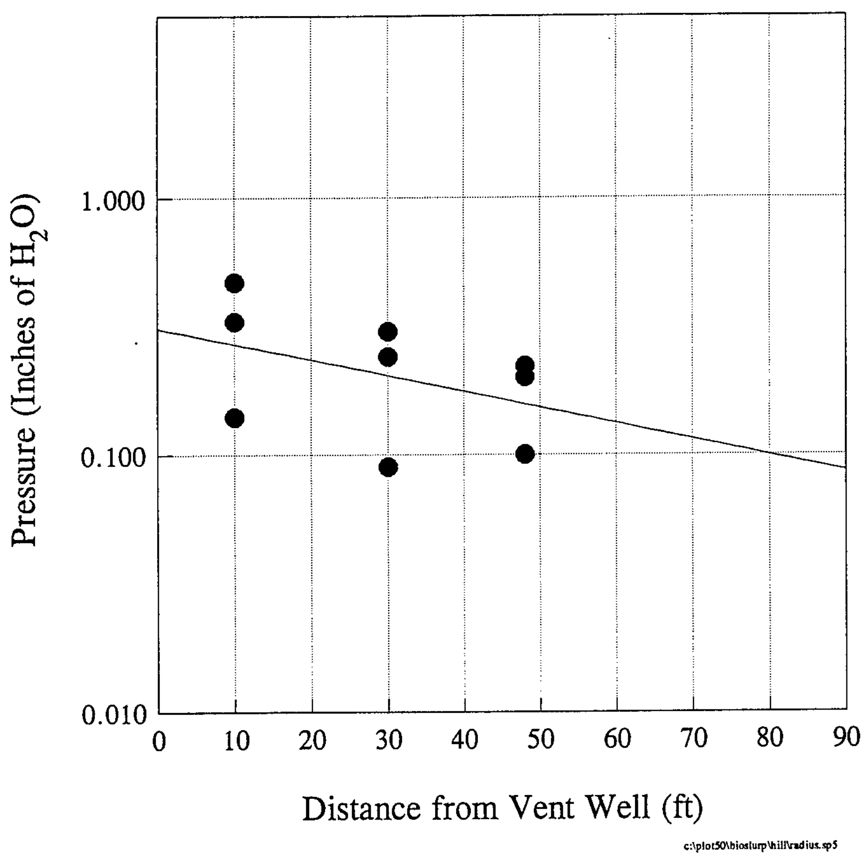


Figure 9. **Soil Gas Pressure Change as a Function of Distance During the Soil Gas Permeability Test**

Table 10. **In Situ Respiration Test Results at Hill AFB, UT**

Monitoring Point	Oxygen Utilization Rate (%/hr)	Biodegradation Rate (mg/kg-day)
OU101-10-24.0′	0.29	4.8
OU101-10-8.0′	0.61	9.9
OU101-30-8.0′	0.67	11
OU101-48-8.0′	0.72	12

5.0 DISCUSSION OF RESULTS AT LANDFILL 3, OU1

Skimmer and drawdown pumping were not as effective as bioslurping at recovering LNAPL at this site. Free product recovery rates were lower on average during skimmer and drawdown pumping, with average LNAPL recovery rates of 0.80 gallons/day during the skimmer pump test and 0.50 gallons/day during the drawdown pump test. In contrast, LNAPL recovery rates during bioslurping initially were approximately 7.5 gallons/day and stabilized at approximately 1.5 gallons/day after the first day.

Groundwater recovery rates during the bioslurper pump test were high in comparison to rates during the skimmer pump tests, but were comparable to recovery rates during the drawdown pump test. On average, groundwater was extracted at rates of 260 gallons/day during skimming, 1,500 gallons/day during bioslurping, and 2,400 gallons/day during drawdown pumping.

Soil gas concentrations were measured at monitoring points during the bioslurper pump test to determine whether the vadose zone was being oxygenated. Oxygen concentrations changed little until the end of the bioslurper pump test. At this time, oxygen concentrations increased slightly at depths of 16 and 24 ft at all distances from the bioslurper well. Over time, it is likely that the area would become well oxygenated. These results correlate with the radius of influence of 80 ft determined during the soil gas permeability test.

Implementation of bioslurping at the Hill AFB test site probably would facilitate enhanced recovery of LNAPL from the water table and simultaneous in situ biodegradation of hydrocarbons in the vadose zone via bioventing. Bioslurping will result in extraction of significant quantities of

groundwater; however, if disposal at the Industrial Wastewater Treatment Plant is permissible, this will not impact the economic viability of bioslurping.

6.0 METHODS AND RESULTS AT BUILDING 870

Monitoring well MW-14 was evaluated for use in the bioslurper pilot testing. Initial depths to LNAPL and to groundwater were measured using an oil/water interface probe (ORS Model #1068013). LNAPL was removed from the well with a Teflon™ bailer until the LNAPL thickness could no longer be reduced. The rate of increase in the thickness of the floating LNAPL layer was monitored for approximately 26 hours using the oil/water interface probe. Results from the baildown test in monitoring well MW-14 are presented in Table 11. A total volume of 8 L (2.1 gallons) was removed by hand bailing. The LNAPL thickness did not recover to initial levels by the end of the 26-hour test period. The initial free-product thickness was approximately 7.8 ft and the free-product thickness at the end of the test period was approximately 1.1 ft.

Upon completion of the baildown test, preparations were made to begin a short-term bioslurper pump test. Setup for the bioslurper pump test was the same as that described in Section 3.5.3. The liquid ring pump was started on November 7, 1995, to begin the bioslurper pump test and was operated intermittently for approximately 43 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. Only minimal quantities of free product were recovered, with a total volume of 0.2 gallons collected at an average rate of 0.11 gallons/day. In contrast, large volumes of groundwater were recovered, with a total volume of 2,033 gallons collected at an average rate of 1,100 gallons/day. These results indicated that this site was not suitable for bioslurping probably due to the small quantities of free product.

Table 11. Results of Baildown Testing in Monitoring Well MW-14

Sample Collection Time (Date-Time)	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
Initial Reading 11/2/95-0923	25.57	17.81	7.76
11/2/95-0952	20.07	20.05	0.02
11/2/95-0953	20.41	20.21	0.20
11/2/95-0954	20.26	20.05	0.21
11/2/95-0955	20.17	19.89	0.28
11/2/95-0956	20.11	19.80	0.31
11/2/95-0957	20.08	19.72	0.36
11/2/95-0958	20.04	19.64	0.40
11/2/95-1000	20.01	19.57	0.44
11/2/95-1002	20.00	19.54	0.46
11/2/95-1003	19.99	19.53	0.46
11/2/95-1004	19.99	19.50	0.49
11/2/95-1005	19.99	19.48	0.51
11/2/95-1006	19.99	19.47	0.52
11/2/95-1007	19.99	19.46	0.53
11/2/95-1009	19.99	19.45	0.54
11/2/95-1010	20.00	19.44	0.56
11/2/95-1011	20.00	19.44	0.56
11/2/95-1012	20.00	19.43	0.57
11/2/95-1013	20.00	19.42	0.58
11/2/95-1014	20.00	19.415	0.59
11/2/95-1016	20.00	19.41	0.59
11/2/95-1017	20.00	19.41	0.59
11/2/95-1018	20.00	19.40	0.60
11/2/95-1019	20.01	19.40	0.61
11/2/95-1020	20.01	19.39	0.62
11/2/95-1021	20.01	19.39	0.62
11/2/95-1022	20.01	19.39	0.62

Table 11. Results of Baildown Testing in Monitoring Well MW-14 (continued)

Sample Collection Time (Date-Time)	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
11/2/95-1023	20.01	19.38	0.63
11/2/95-1024	20.01	19.38	0.63
11/2/95-1026	20.01	19.375	0.64
11/2/95-1027	20.01	19.375	0.64
11/2/95-1028	20.02	19.37	0.65
11/2/95-1030	20.02	19.37	0.65
11/2/95-1032	20.03	19.36	0.67
11/2/95-1033	20.03	19.36	0.67
11/2/95-1034	20.03	19.36	0.67
11/2/95-1036	20.03	19.35	0.68
11/2/95-1037	20.04	19.35	0.69
11/2/95-1038	20.04	19.35	0.69
11/2/95-1039	20.05	19.35	0.70
11/2/95-1042	20.05	19.35	0.70
11/2/95-1044	20.05	19.35	0.70
11/2/95-1046	20.05	19.345	0.71
11/2/95-1048	20.05	19.34	0.71
11/2/95-1050	20.05	19.34	0.71
11/2/95-1054	20.07	19.34	0.73
11/2/95-1058	20.07	19.34	0.73
11/2/95-1103	20.08	19.34	0.74
11/2/95-1108	20.09	19.33	0.76
11/2/95-1118	20.11	19.31	0.80
11/2/95-1128	20.11	19.31	0.80
11/2/95-1310	20.17	19.27	0.90
11/2/95-1445	20.21	19.25	0.96
11/2/95-2034	20.31	19.27	1.04
11/3/95-0715	20.40	19.29	1.11
11/3/95-1131	20.38	19.26	1.12

7.0 REFERENCES

Battelle. 1995. *Test Plan and Technical Protocol for Bioslurping*, Report prepared by Battelle Columbus Operations for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Rev. 2), Report prepared by Battelle Columbus Operations, U.S. Air Force Center for Environmental Excellence, and Engineering Sciences, Inc. for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

APPENDIX A

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER FIELD ACTIVITIES AT HILL AFB, UTAH

Battelle
. . . Putting Technology To Work

505 King Avenue
Columbus, Ohio 43201-2693
Telephone (614) 424-6424
Facsimile (614) 424-5263

October 24, 1995

Headquarters, Air Force Center
for Environmental Excellence
8001 Arnold Drive (Bldg. 642)
Brooks AFB, TX 78235-5357

Attention: Mr. Patrick Haas

Dear Patrick:

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER TESTING AT HILL AFB CONTRACT NO. F41624-94-C-8012

This brief letter report is the site specific test plan for bioslurper field activities at Hill Air Force Base, Utah. This site-specific test plan outlines the field activities to be performed at the OU1 site at Hill AFB. General field procedures are outlined in the accompanying generic "Test Plan and Technical Protocol for Bioslurping." We would like to begin field activities October 27, 1995, with well installation and soil sampling. The bioslurper field test would be completed over the next 2 weeks.

TEST PLAN FOR BIOSLURPER FIELD ACTIVITIES AT HILL AFB, UTAH

The Air Force Center for Environmental Excellence is conducting a nationwide application of an innovative technology for free-product recovery and soil bioremediation. The technology tested in the Bioslurper Initiative is vacuum-mediated free-product recovery/bioremediation (bioslurping). The field test and evaluation are intended to demonstrate the initial feasibility of bioslurping by measuring system performance in the field. System performance parameters, mainly free-product recovery, will be determined at numerous sites. Field testing will be performed at many sites to determine the effects of different organic contaminant types and concentrations and different geologic conditions on bioslurping effectiveness.

Plans for the field test activities are presented in two documents. The first is th overall test plan and technical protocol for the entire program titled, *Test Plan and Technical Protocol for Bioslurping* (January, 1995). The overall plan is supplemented by plans specific for each test site. This letter report is the site-specific supplement for Hill Air Force Base, Utah.

The overall test plan and protocol was developed as a generic plan for the Bioslurper Initiative to improve the accuracy and efficiency of test plan preparation. The field program requires installation and operation of the bioslurping system supported by a wide variety of site characterization, performance monitoring, and chemical analysis activities. The basic methods to be applied from site to site do not change. Preparation and review of the overall plan allows efficient documentation and review of the basic approach to the test program. Details required for application at each site are covered by individual supplements for that site. The concise site-specific plan effectively communicates regulatory background to base personnel. This letter report was prepared based on site-specific information received by Battelle from Hill AFB and other pertinent site-specific information to support the generic test plan.

Site Descriptions

Operable Unit 1 is located near the northeast boundary of Hill AFB, and as depicted in Figure 1, contains Landfills 3 and 4, Chemical Disposal Pits (CDPs) 1 and 2, the Waste Phenol Pit, and the Base golf course. Monitoring well MW U101 in Landfill 3 and MW U069 in CDP 1 are the wells to be evaluated for use in the short-term pilot test. Well MW U101 the most likely location for the pilot test based on results of a previous bioslurper pilot test conducted by Hill AFB in 1993. Well MW U101 produced approximately 7 gallons of fuel in a 24-hour extraction period, while well MW U069 produced negligible recovery (Battelle unpublished data). The purpose of this bioslurper test will be to assess the relative efficacy of bioslurping for fuel recovery compared to passive skimming and pump drawdown technologies.

Since soil gas monitoring points are already present next to MW U101 a new monitoring well will be installed adjacent to OU-101 during soil sampling activities. The new well will be used as the bioslurper extraction well or for radius of influence testing during the pilot test.

Landfill 3 was operated as a general refuse landfill from 1947 through 1967. Materials dumped and burned at Landfill 3 included industrial sludge, waste solvents, and residues from solvent cleaning operations (Montgomery Watson, 1993). Relevant data for MW U101 and MW U069, including well construction data and site geology, are presented in Appendix A.

Project Activities

The following field activities are planned for the pilot test to be conducted at Hill AFB. Additional details about the activities are presented in the *Test Plan and Technical Protocol for Bioslurping*. Table 1 shows the schedule of activities for the OU1 site at Hill AFB.

1. Mobilization to the Site

When the site-specific test plan has been approved, Battelle staff will mobilize equipment to the test site. All equipment will be shipped via truck and trailer to Hill AFB. Battelle personnel will be mobilized to the site with all the equipment. The Battelle POC will provide the Air Force POC with personal information for each Battelle employee who will be on site. The exact mobilization date will be confirmed with the Base POC as far in advance of fieldwork as is possible.

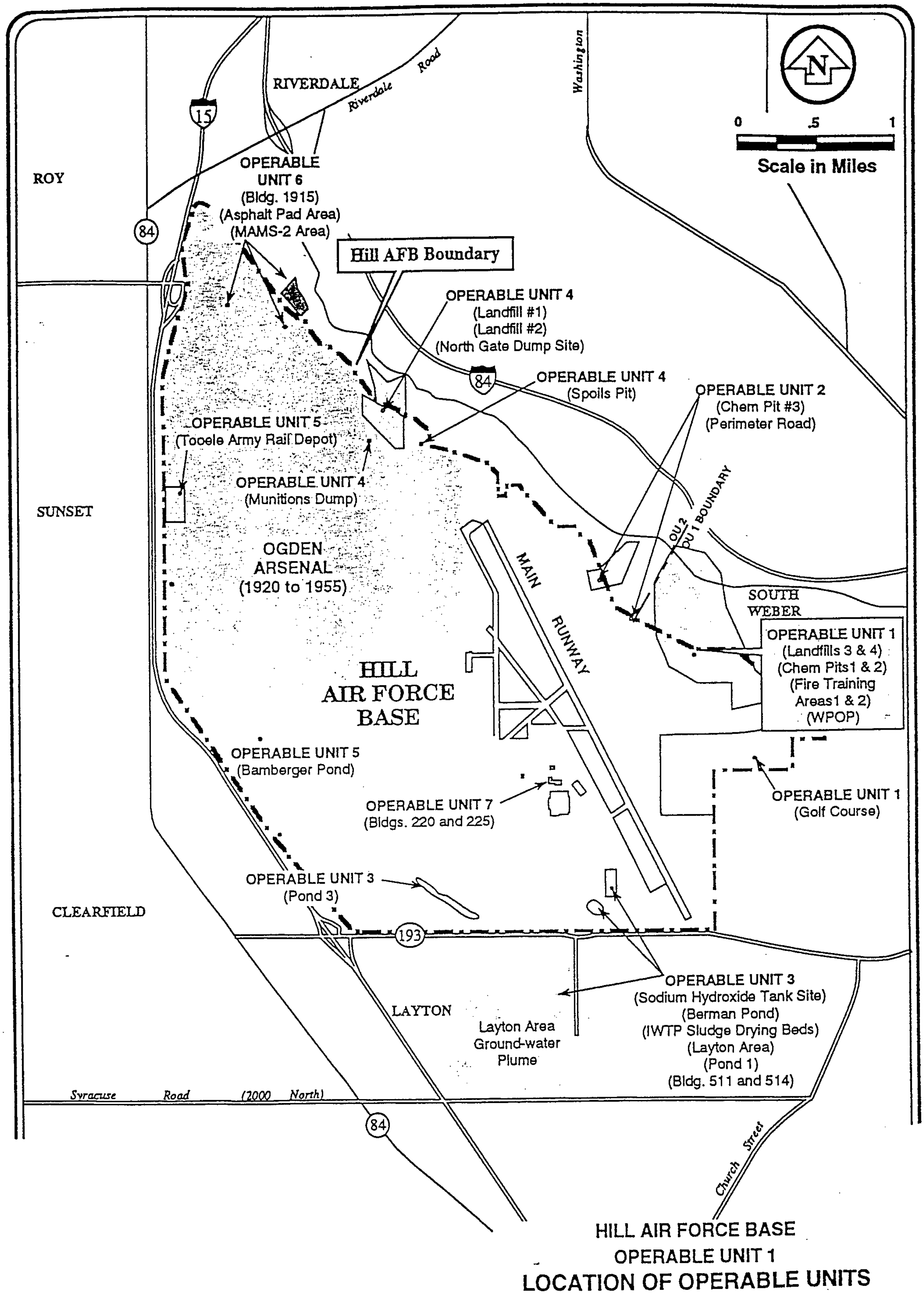


Figure 1. Location of OU1 at Hill Air Force Base

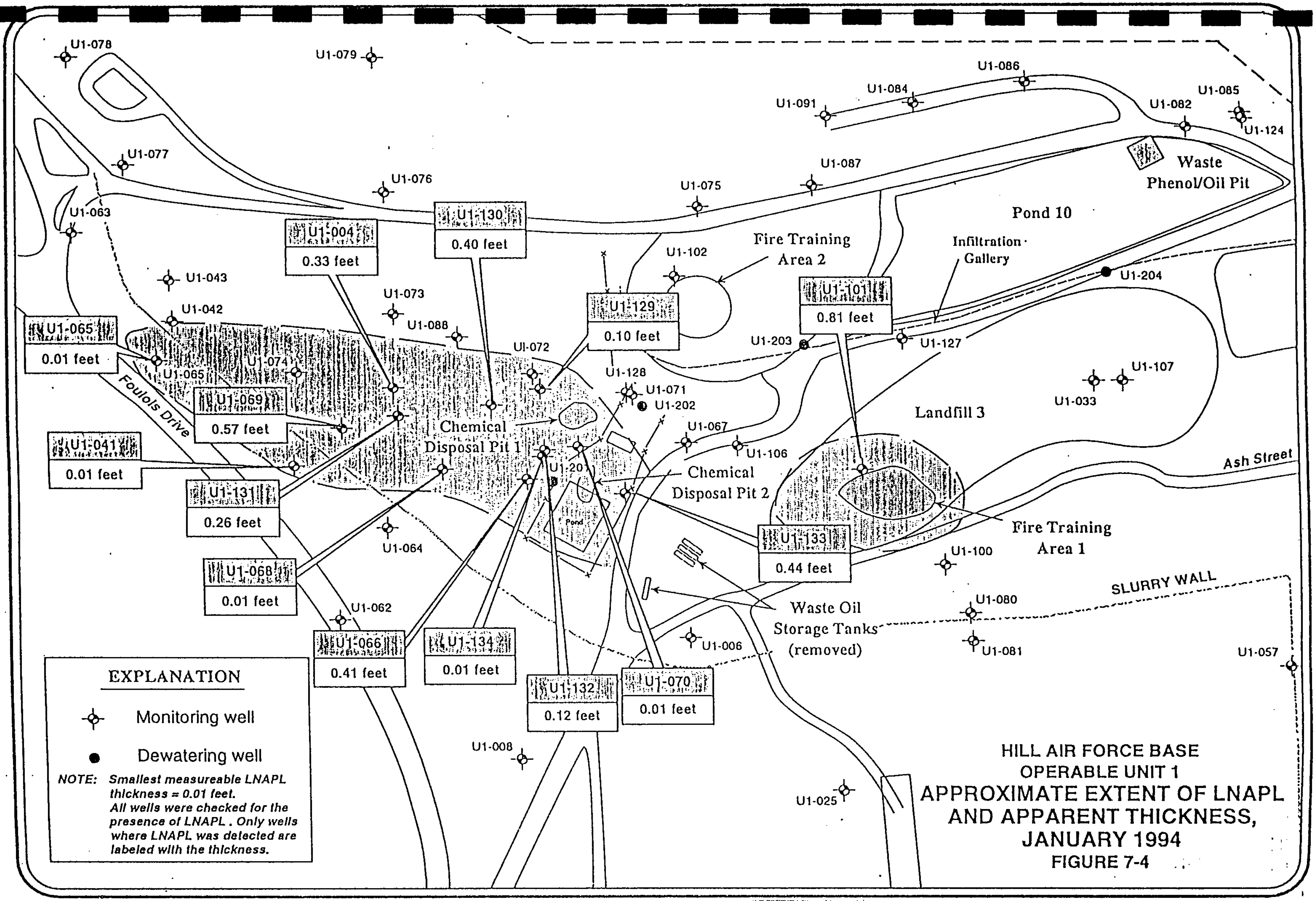


Figure 2. Well and Boring Locations OU1

TABLE 1. SCHEDULE OF BIOSLURPER TEST ACTIVITIES

Pilot Test Activity	Schedule
Test Plan Approval	day (to be determined)
Mobilization	day 1-2
Site Characterization	day 2-3
Baildown Tests	
Soil Gas Survey (limited)	
Extraction Well Installation (3 MPs are already present on the site)	
Soil Sampling	
System Installation	day 2-3
Test Startup	day 4
Skimmer Test (2 day)	day 4
Bioslurper Pump Test (4 days)	day 5-9
Air Permeability Testing	day 5
Skimmer Test (1 day)	day 9
Drawdown Pump Test (2 day)	day 10-11
In Situ Respiration Test (air/helium injection)	day 10
In Situ Respiration Test (monitoring)	day 10-12
Demobilization/Mobilization	day 12-14

2. Site Characterization Tests

2.1 *Soil Gas Survey (Limited)*

The soil gas survey will be conducted in the existing soil gas monitoring points. The soil gas survey will be used to assist in locating the new extraction well to be installed at the site. To obtain further information about the soil gas survey, consult Section 5.2 of the *Test Plan and Technical Protocol for Bioslurping*.

2.2 *Baildown Tests*

The baildown test is used to assess the mobility and recoverability of LNAPL in site monitoring wells. Baildown tests will be performed at wells that contain measurable LNAPL thicknesses to estimate the LNAPL recovery potential at those particular wells. Detailed procedures for the baildown tests are provided in Section 5.6 of the *Test Plan and Technical Protocol for Bioslurping*.

2.3 *Soil Sampling*

Soil sampling will be done to assess soil contaminant and physical characteristics. The scope of soil sampling activities is limited to contaminant screening and does not represent pretreatment characterization. Soil samples from the chosen site will be collected from the borehole advanced for monitoring well installation. Two to three soil samples will be collected from the site. Samples will be collected across the capillary fringe to characterize the soils which affect LNAPL mobility.

Soil samples will be analyzed for particle size distribution; bulk density; porosity; moisture content; benzene, toluene, ethylbenzene, and xylenes (BTEX); and TPH. Section 5.5.1 of the *Test Plan and Technical Protocol for Bioslurping* will be consulted for information on the field measurements and sample collection procedures for soil sampling.

3. Bioslurper System Installation and Operation

Once the well to be used for the bioslurper test installation at Hill AFB has been identified, the bioslurper system and support equipment will be installed and operated.

3.1 *System Setup*

All the previously transported equipment will be mobilized to the selected extraction well, and the bioslurper system will be assembled. Figure 3 shows a flow diagram of the bioslurper process. Prior to the initiation of the LNAPL recovery tests, all the relevant baseline field data will be collected and recorded. These data will include soil gas concentrations, initial soil gas pressures, the depth to groundwater, and the LNAPL thickness. Also, ambient soil and relevant atmospheric conditions (weather conditions, temperature, humidity, barometric pressure, etc.) will be recorded. All emergency equipment (i.e., emergency shutoff switches and fire extinguishers) will be installed and checked for proper operation at this time.

A clear level area near the selected extraction well must be identified for the 20-ft by 10-ft flatbed trailer that carries the 7.5-hp pump and all other equipment required for the bioslurper system operation. For more information on the bioslurper system installation, consult Section 6.0 of the *Test Plan and Technical Protocol for Bioslurping*.

3.2 *System Shakedown*

A brief startup test will be conducted to ensure that the system is properly constructed and operates safely. All system components will be checked for problems and/or malfunctions. A checklist will be provided to document the system shakedown.

3.3 *System Startup and Test Operations*

After installation is complete and the bioslurper system is confirmed to be operating properly, the LNAPL recovery tests will be started. The Bioslurper Initiative has been designed to evaluate the effectiveness of bioslurping as a LNAPL recovery technology relative to conventional gravity-driven LNAPL recovery technologies. The Bioslurper Initiative includes three separate LNAPL recovery tests: (1) a skimmer simulation test; (2) a vacuum-assisted bioslurper test; and (3) a groundwater drawdown LNAPL recovery test. The three recovery tests are described in detail in Section 7.3 of the *Test Plan and Technical Protocol for Bioslurping*.

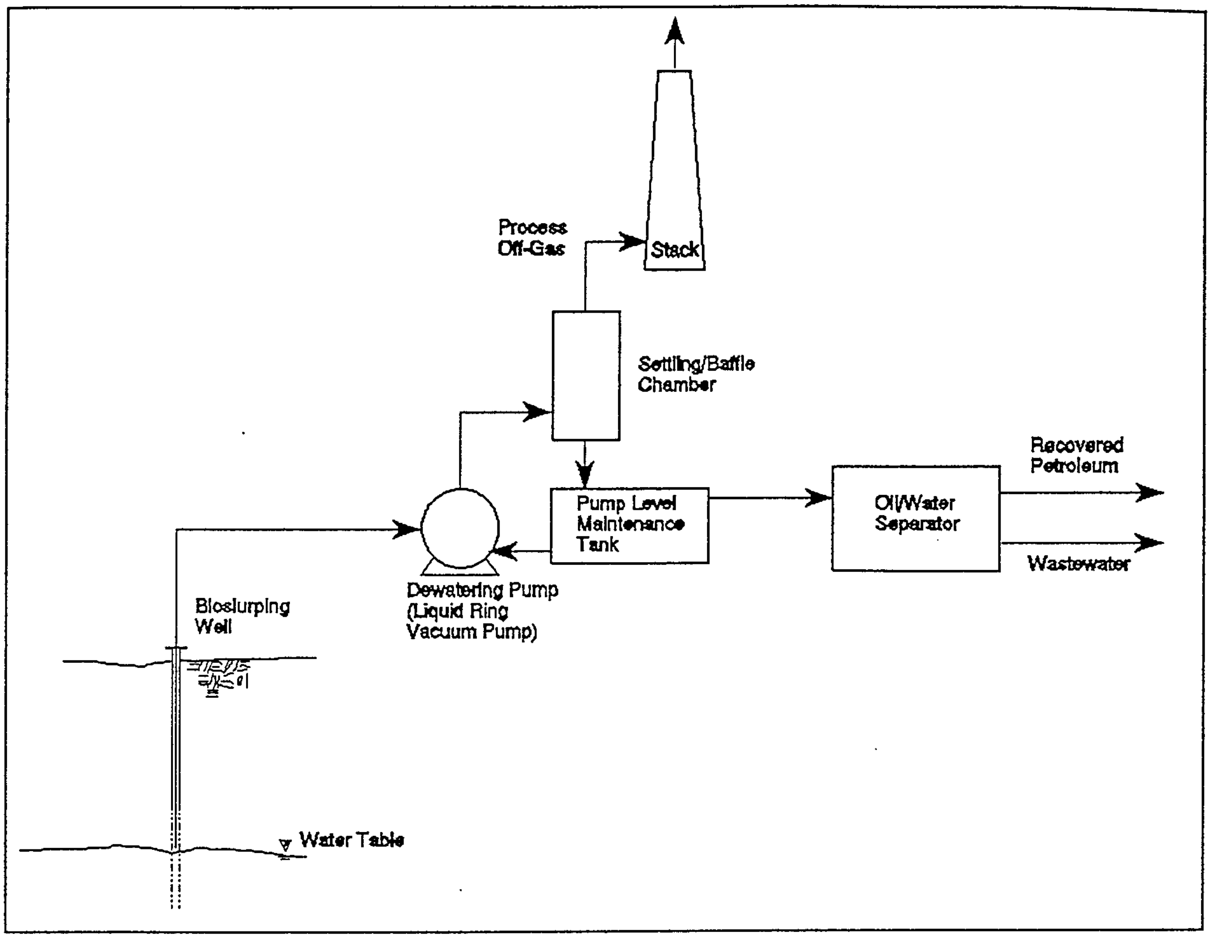


Figure 6. Bioslurper Process Flow.

Bioslurper operating parameters measured during operation are vapor discharge analysis, aqueous effluent analysis, LNAPL recovery volume rates, vapor discharge volume rates, and groundwater discharge volume rates. Vapor monitoring will consist of periodic on-line monitoring of TPH supplemented by two samples collected for detailed laboratory analysis. A total of two samples of aqueous effluent will be collected for analysis of BTEX and TPH content. Recovered LNAPL volume will recorded using an in-line flow-totalizing meter. The off-gas discharge volume will be measured using a calibrated pilot tube, and groundwater discharge volume will recorded using an in-line flow-totalizing meter. Section 8.0 of the *Test Plan and Technical Protocol for Bioslurping* describes the process monitoring of the bioslurper system.

3.4 *Soil Gas Permeability Tests*

A soil gas permeability test will be conducted concurrently with startup of the vacuum-assisted bio-slurper operation. Soil gas permeability data support the process of estimating the vadose zone radius of influence of the bioslurper system. Soil gas permeability results also help in determining the number of wells required if it decided to treat the site with a large-scale bioslurper system. The soil gas permeability test method is described in Section 5.8 of the *Test Plan and Technical Protocol for Bioslurping.*

3.5 *In Situ Respiration Tests*

The rate of oxygen utilization will be used to estimate the biodegradation rate for the site. An in situ respiration test will be conducted after completion of the bioslurper operating tests. The in situ respiration testing will consist of air/helium injection into selected soil gas monitoring points followed by monitoring changes in concentration of oxygen, carbon dioxide, petroleum hydrocarbons, and helium in soil gas near the injection point. Measurement of the soil gas composition typically will be conducted at 2, 4, 6, and 8 hours and then every 4 to 12 hours for about 2 days. Timing of the tests will be adjusted based on oxygen use rate. If oxygen depletion occurs rapidly, more frequent monitoring will be required. If oxygen depletion is slow, less frequent readings will be acceptable. Further information on the procedures and data collection for in situ respiration testing is given in Section 5.9 of the *Test Plan and Technical Protocol for Bioslurping.*

3.6 *Extended Testing*

The Air Force has the option of extending the operation of the bioslurper system for up to 6 months at Hill AFB, if LNAPL recovery rates are promising. If extended testing is to be performed, additional site support will be required. The Air Force will need to provide electrical power for long-term operation of the bioslurper pump. Disposition of all generated wastes and routine operation and maintenance of the system will be the Air Force's responsibility. Battelle will provide technical support during the extended testing operation.

If the extended testing option is exercised, Battelle is scoped to remain on site an additional 2 days after the short-term pilot test is completed. The additional time on site will allow for connection of the bioslurper system to Air Force supplied power. Battelle will provide the base with a detailed operation manual for the bioslurper system and will provide training to Air Force personnel. The Base POC will be provided with a project record book to record system data. The POC will be given a Battelle contact and an alternate contact for technical assistance and will be contacted weekly for updates on system operation. At the end of the extended testing option (up to 6 months of operation) Battelle will return to the site to remove all bioslurper equipment. All waste generated during the operation of the bioslurper system will be the responsibility of the Air Force.

4. Demobilization

Once all the necessary tests have been completed at the Hill AFB sites, all the equipment will be disassembled by Battelle staff. The equipment will then be transported to the next bioslurper site location.

Bioslurper System Discharge

1. Vapor Discharge Disposition

Battelle has been informed by Hill AFB that the bioslurper vapor discharge my be released directly to the atmosphere for the short-term pilot test. To ensure the safety and compliability of the bioslurper system, vapor discharge samples (TPH, O_2, and CO_2) will be collected periodically throughout the bioslurper pilot test. Also, field soil gas screening instruments will be used to monitor vapor discharge concentration variability.

2. Aqueous Influent/Effluent Disposition

It is estimated that the groundwater extraction rate will be less than 5 gpm. Battelle will discharge extracted groundwater directly to a 10,000-gallon wastewater tank. The tank will be periodically discharged to the base industrial wastewater treatment plant (IWTP).

3. LNAPL Recovery Disposition

The bioslurper system will recover free-phase LNAPL from the pilot tests performed at Hill AFB. LNAPL recovered by the bioslurping tests will be turned over to the Base for disposal and/or recycling. The volume of free product recovered from the Base will not be known until the tests have been performed. The maximum expected fluid recovery rate for this test is 5 gpm. However, the actual rate of LNAPL recovery will be much lower.

Schedule

Drilling activities at OU1 are scheduled to begin on October 27, 1995. The bioslurper pilot test will begin immediately after drilling activities are complete.

Project Support Roles

This section outlines the some of the major functions of personnel from Battelle, Hill AFB, and AFCEE during the bioslurper field test.

1. Battelle Activities

The obligations of Battelle in the Bioslurper Initiative at Hill AFB will be to supply all the necessary staff and equipment to perform the initial pilot-tests on the bioslurper system. Also Battelle will provide technical support in the areas of water and vapor discharge permitting, digging permits, technical support during the extended testing period, and any other technical areas that need to be addressed.

2. Hill AFB Support Activities

To conduct the necessary field tests at Hill AFB, the Base must be able to provide the following items:

a. Any and all digging permits and utility clearances that need to be obtained prior to the initiation of the fieldwork. Any underground utilities should be clearly marked to reduce the chance of utility damage and/or personal injury during soil gas probe and well installation (if needed). Battelle will not begin field operations without these clearances and permits.

b. The Air Force will be responsible for obtaining Base and site clearance for the Battelle staff that will be working at the Base. The Base POC will be furnished with all the pertinent personal information for each staff member prior to field startup.

c. Access to the IWTP sewer must be furnished, so that staff can discharge the bioslurper aqueous effluent directly to the Base treatment facility.

d. Regulatory approval, if any is required, will need to be obtained by the Base POC prior to startup of the bioslurper pilot test.

e. The Base also will be responsible for the disposition of all waste generated from the pilot testing. Such waste includes any soil cuttings generated from drilling, and all aqueous wastestreams produced from the bioslurper tests. Also, all free product recovered from the bioslurper operation will be disposed of or recycled by the Base. Battelle will provide technical assistance in disposing of the waste generated from the bioslurper pilot test.

f. The Health and Safety Plan for Hill AFB will be finalized with information provided by the Base POC. Table 2 is a checklist for the necessary information required to complete the Health and Safety Plan.

3. AFCEE Activities

The Air Force Center for Environmental Excellence (AFCEE) POC will act as a liaison between Battelle and Hill Base staff. The AFCEE POC will ensure that all necessary permits are obtained and the required space to house the bioslurper field equipment is found. The following is a listing of Battelle, AFCEE, and Hill Base staff that can be contacted in cases of emergency and/or required technical support during the bioslurper field initiative tests at Hill AFB:

Battelle POCs	—	Jeff Kittel	614-424-6122
		Greg Headington	614-424-5417
AFCEE POC	—	Patrick Haas	210-536-4331
Hill AFB POC	-	Darrin Wray	801-777-8790 ext.360

TABLE 2. HEALTH AND SAFETY INFORMATION CHECKLIST

The following emergency information will be obtained by the Site Health and Safety Officer prior to beginning operations:

Emergency Contacts	Name	Telephone No.
Hospital Emergency Room:	____________	____________
Point of Contact:	____________	____________
Fire Department:	____________	____________
Emergency Unit (Ambulance):	____________	____________
Security:	____________	____________
Explosives Unit:	____________	____________
Community Emergency Response Coordinator:	____________	____________
Other:	____________	____________

Program Contacts

Air Force: ____

Battelle: ____

Other: ____

Emergency Routes

Hospital (maps attached): ____

____

Other: ____

If you have any questions, please feel free to call me at (614) 424-6122.

Sincerely,

Jeffrey A. Kittel
Program Manager
Environmental Restoration Department

JAK:gm
cc: Darrin Wray (Hill AFB)

APPENDIX A

Ui - 101

Project: Hill Air Force Base
Date Drilled: 8-22-92 Date Completed: 8-22-92
Logged By: Mark Loucks
Drilling Contractor: Layne Environmental
Drilling Method: Mobile Drill B-80

JMM Boring No.: M-63 (SB-28)
Northing: 289,349.9 Easting: 1,874,419.9
Ground Surface Elevation (ft.): 4,798.95
Measuring Point (MP) Elevation (ft.): 4,800.71
MP is Top of Casing Datum: NGVD (1929)

Borehole: Total Depth (ft.) 33.5 Diameter (in.) 8 1/4
Well Screen: Diameter (in. I.D.) 2 Depth (ft.) 31–21 Type 304 Stainless Steel Slot Size 0.010 inch
Blank Casing: Diameter (in. I.D.) 2 Length (ft.) 21–0 Type PVC Schedule 40
Interval: Sand (ft.) 33.5–16.2 Bentonite Seal (ft.) 16.2–14.2 Cement Grout Seal (ft.) 14.2–0
Depth to Water from MP (ft) 28.3 Date Measured 8-22-92

DEPTH (FEET)	GRAIN SIZE % GRAVEL	% SAND	% FINES	MAX. PID READING (ppm)	BLOWS (6 IN.)	SAMPLE TYPE*	LITHOLOGIC LOG	ELEVATION (FEET)
0	10	30	60	0			Fill—silt with sand and gravel; (7.5YR6/6); coarse to fine sand, rounded to subangular; fine gravel; loose; dry.	4,799.0
					6			
		30	70	1			Fill—silt with sand; (7.5YR6/6); fine to medium sand, rounded to subangular; dense; slightly moist.	
					10	C		
1								4,798.0
					17			
							Same as above.	
				0	10			
2								4,797.0
				0	14			
						C		
				0	16		Fill—sand with silt and gravel; (7.5YR6/4); fine to coarse sand, rounded to subangular; fine to coarse gravel, rounded to subangular; loose to medium dense; slightly moist.	
3								4,796.0
					20			
	30	35	35	11	11		Fill—poor recovery, sand with silt, clay, and gravel; fine to coarse sand, rounded to subangular; fine to coarse gravel, rounded to subangular; high plasticity clay, soft; medium dense to dense; moist; hydrocarbon staining in much of the sample.	
4								4,795.0
					16	C		
					27			

SAMPLE RECOVERY | GRAPHIC LOG | WELL COMPLETION DETAIL

8 1/4" Borehole
Grout
2" Schedule 40 PVC Casing

JMM James M. Montgomery

*C California Split Spoon Sampler (2.5" I.D.)
S Standard penetration test sampler
c Cuttings
▼ Elevation of ground water

HILL AIR FORCE BASE
UI - 101 M-63 (SB-28)

PROJECT NO. 2208.0504

UI-101

Project: Hill Air Force Base

JMM Boring No.: M-63 (SB-28)

DEPTH (FEET)	% GRAVEL	% SAND	% FINES	MAX. PID READING (ppm)	BLOWS (6 IN.)	SAMPLE TYPE*	LITHOLOGIC LOG	WELL COMPLETION DETAIL	ELEVATION (FEET)
5	20	60	20	104	7		Fill—sand with gravel and silt; (10YR3/1); fine to medium sand, rounded to subangular; fine to coarse gravel, rounded to subrounded; loose; moist; hydrocarbon stained throughout; glass fragments.		4,794.0
					14	C			
		40	60	87			Fill—clay with sand and silt; (7.5YR6/6); clay, soft, high plasticity; medium to fine sand, thin lenses up to 0.5 cm thick; loose; moist; hydrocarbon staining in sand lenses, not in clay.		
6								Grout	4,793.0
					16				
					9		As above with very poor recovery.		
7									4,792.0
					16			2" Schedule 40 PVC Casing	
						C			
					18				
8									4,791.0
					21				
	10	45	45	0	14		Fill—sand with silt, clay, and gravel; (10YR3/2); fine to coarse sand, rounded to subangular; fine gravel, rounded to angular; clay, high plasticity, soft; moist; some hydrocarbon staining.		
9									4,790.0
					20	C			
					27				
10									4,789.0
		65	35	27	1		Sand with silt; (10YR3/2); medium to fine sand; loose; moist; hydrocarbon staining in most of sample.		
				30	1	C			
11									4,788.0
					1				
	5	95		5	8		Fill—sand with gravel; (10YR6/6); fine to coarse sand, rounded to subangular; fine gravel, rounded to subrounded; loose; moist; 10-20% dark, asphalt type balls up to 1.5 cm thick composed of sand and fine gravel, crumble at touch.		
12									4,787.0
				3	11				
	40	60		0		C	Fill—sand with gravel; (10YR4/2); coarse to fine sand, trace silt balls, rounded to subangular; fine to coarse gravel, rounded to subangular; loose; moist; trace hydrocarbon staining.		
					17				
13									4,786.0
					24				
		80	20	19	37		Fill—sand with silt; (10YR3/2); fine to coarse sand, rounded to subangular; loose; moist; hydrocarbon staining.		
14									4,785.0
	40	60		35	62	C	Fill—sand with gravel; (10YR7/3); fine to coarse sand, rounded to subangular; fine to coarse gravel up to 5 cm in diameter, rounded to subangular; trace silt; loose to dense; slightly moist; trace hydrocarbon staining around gravels.	1/4" Bentonite Pellets	
				189	77				

JMM James M. Montgomery

* C California Split Spoon Sampler (2.5" I.D.)
S Standard penetration test sampler
c Cuttings
▼ Elevation of ground water

HILL AIR FORCE BASE
M-63 (SB-28)

UI-101

PROJECT NO. 2208.0504

Project: Hill Air Force Base

JMM Boring No.: M-63 (SB-28)

Depth (ft)	Grain Size								Lithologic Log
15	20	80		85	17				Fill—sand with gravel; (10YR7/2); fine to coarse sand, rounded to subangular; fine gravel, rounded to subangular; trace silt; loose to medium dense; slightly moist.
	35	65		65	33	C			Sand with gravel; (10YR7/2); fine to coarse sand, rounded to angular; fine to coarse gravel, rounded to subangular; trace silt; loose to medium dense; slightly moist.
16					36				
	5	95		27	18				Fill—sand; (10YR6/2); fine to medium sand, rounded to subangular; fine gravel, rounded to subrounded; medium dense; slightly moist.
17	45	55		21	25	C		SP	Sand with gravel; (10YR5/2); medium to coarse sand; fine to coarse gravel up to 4 cm in diameter; medium dense; slightly moist.
					21				
18					32				
	25	55	20	48	14			SM	Sand with gravel and silt; (10YR4/2); fine to coarse sand, rounded to subangular; fine to medium gravel, rounded to subangular; loose to medium dense; slightly moist.
19				44	23	C			
					31				
20	5	95		39	13			SW	Sand; (10YR5/2); medium to coarse sand, rounded to subangular; fine gravel, rounded to subrounded; medium dense to dense; moist.
	25	75		32	23	C			Sand with gravel; (10YR5/2); coarse to fine sand, rounded to subangular; fine to coarse gravel, rounded to subangular; dense to medium dense; moist; trace algal balls up to 0.5 cm in diameter, yellowish green.
21					25				
	20	80		230	19				Sand with gravel; (10YR5/2); fine to coarse sand, rounded to subangular; fine to medium gravel, rounded to subangular; trace silt; loose to medium dense; moist.
22	40	55	5	790	23	C			Sand with gravel; (10YR4/0); fine to coarse sand, rounded to subangular; fine to coarse gravel, rounded to subangular; reddish brown silt; medium dense; hydrocarbon staining; soils gray.
					36				
23	70	30		1186	34			GW	Gravel with sand; (10YR2/1); fine to coarse gravel, rounded to subangular; coarse to fine sand, rounded to subangular; loose to medium dense; moist; heavy black hydrocarbon coating over sample.
					37	C			
24					41				
					30				

Elevations: 4,784.0 (15 ft); 4,783.0 (16 ft); 4,782.0 (17 ft); 4,781.0 (18 ft); 4,780.0 (19 ft); 4,779.0 (20 ft); 4,778.0 (21 ft); 4,777.0 (22 ft); 4,776.0 (23 ft); 4,775.0 (24 ft)

Well construction: 1/4" Bentonite Pellets; #32-40 Sand; 2" Schedule 40 PVC Casing; 0.010" Type 304 S.S. Screen

JMM James M. Montgomery

- C California Split Spoon Sampler (2.5" I.D.)
- S Standard penetration test sampler
- c Cuttings
- ▼ Elevation of ground water

HILL AIR FORCE BASE

Ul - 101 M-63 (SB-28)

Project: Hill Air Force Base

JMM Boring No.: M-63 (SB-28)

LITHOLOGIC LOG

Depth (ft)	Grain size				Blow counts	Sampler	USCS	Lithologic description	Elevation
25				252	17		GW	Gravel with sand; (10YR2/1); fine to coarse gravel, rounded to subangular; coarse to fine sand, rounded to subangular; loose to medium dense; moist; heavy black hydrocarbon coating over sample.	4,774.0
	10	45	45	1315	25	C	ML	Silt with sand and gravel; (10YR5/1); fine to coarse sand, rounded to subangular; fine gravel, rounded to subangular; dense; dry.	
26	5	95			31		SW	Sand; (10YR4/1); medium to coarse sand, rounded to subangular; fine to medium gravel, rounded; moderately dense; saturated to very moist; possible LNAPL in soils	4,773.0
27	45	55		538 137	11 27 37	C		Sand with gravel; (10YR4/2); fine to coarse sand, rounded to subangular; fine to coarse gravel, rounded to subangular; medium dense to dense; saturated.	4,772.0
28	15	85		777	22			Sand with gravel; (10YR4/2); fine to coarse sand, rounded to subangular; fine gravel, rounded to subangular; medium dense; saturated; product sheen in sampler.	4,771.0
29	50	50		1285	17 33 34	C	SW/GW	Sand with gravel/gravel with sand; (10YR5/1); coarse to fine sand; rounded to subangular; fine to coarse gravel, rounded to subangular; medium dense to dense; saturated.	4,770.0
30	30	70			17		SW	Sand with gravel; (10YR3/1); fine to coarse sand, rounded to subangular; fine gravel, rounded to subangular; medium dense; saturated.	4,769.0
31	60	40			6 14	C	GW	Gravel with sand; (10YR3/1); fine to coarse gravel, rounded to subangular; coarse to fine sand, rounded to subangular; loose to medium dense; saturated.	4,768.0
32	5	95			11 10		SW	Sand; (10YR2/1); fine to coarse sand, rounded to subangular; trace fine gravel, rounded; medium dense to dense; saturated.	4,767.0
33	60	40			12	C	GW	Gravel with sand; (10YR3/1); fine to coarse gravel, rounded to subangular; coarse to fine sand, rounded to subangular; trace silt; loose to medium dense; moist.	4,766.0
		20	80		15		ML	Silt with sand; (7.5YR6/6); fine sand, rounded to subangular; dense; moist.	
34									4,765.0

T.D. 33.5'

Well construction: #32-40 Sand; 0.010" Type 304 S.S. Screen with S.S. End cap

JMM James M. Montgomery

- C — California Split Spoon Sampler (2.5" I.D.)
- S — Standard penetration test sampler
- c — Cuttings
- ▼ — Elevation of ground water

HILL AIR FORCE BASE
M-63 (SB-28)

Ui-101

TABLE 7-4

SUMMARY OF VOC, BNAE, PESTICIDE/PCB, DIOXIN/FURAN AND TPH RESULTS FOR LNAPL SAMPLES COLLECTED AT FIRE TRAINING AREA 1 DURING THE PHASE II RI

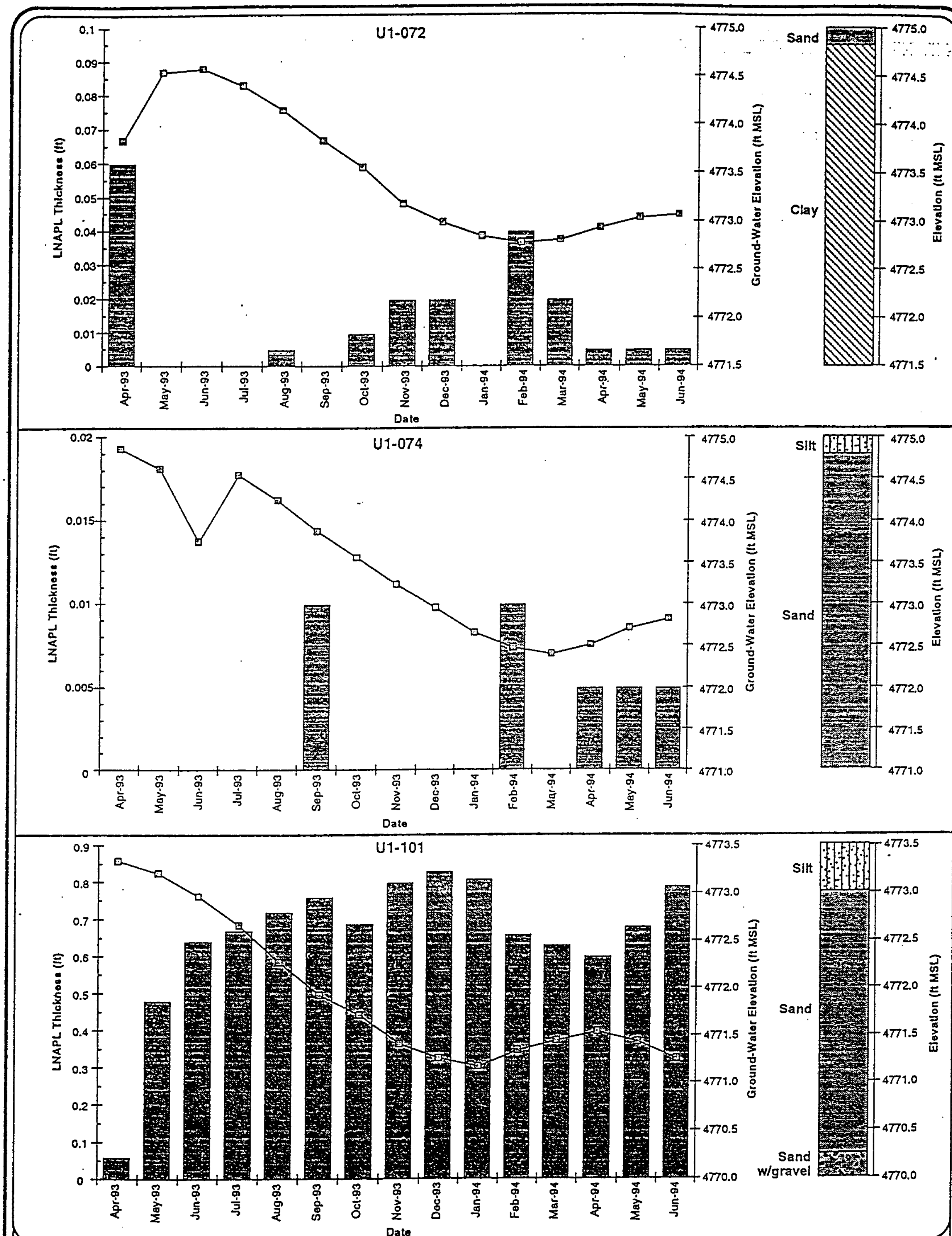
Analytes	Results	
Sample Location:	U1-101	U1-101 (Blind Duplicate Sample)
VOCs (µg/kg)		
Acetone	<43,000	1,100,000[(a)]
Ethylbenzene	210,000	200,000
Total xylene	540,000	<23,250
BNAEs (µg/kg)		
Naphthalene	1,400,000	1,500,000
2-Methylnaphthalene	520,000 J	540,000
Pesticides (µg/ml)		
Alpha-BHC	0.65	0.51
Delta-BHC	<0.05	0.11
Lindane	<0.05	0.39
Dieldrin	0.08	0.08
Endosulfan Sulfate	<0.25	0.37
Furans (pg/ml)		
TCDFs (total)	8,300	3,700
2,3,7,8-TCDF	1 g	89 g
PeCDFs (total)	3,300	1,800
1,2,3,7,8-PeCDF	<96	88
2,3,4,7,8-PeCDF	220	200
HxCDFs (total)	1,600	1,300
1,2,3,4,7,8-HxCDF	160	160
1,2,3,6,7,8-HxCDF	150	140
2,3,4,6,8-HxCDF	180	110
1,2,3,7,8,9-HxCDF	<57	26
HpCDFs (total)	480	690
1,2,3,4,6,7,8-HpCDF	480	410
1,2,3,4,7,8,9-HpCDF	<54	69
OCDF	<220	210
Dioxins (pg/ml)		
TCDDs (total)	220	430
2,3,7,8-TCDD	<16	17
PeCDDs (total)	340	800
1,2,3,7,8-PeCDD	<54	70
HxCDDs (total)	1,200	2,100
1,2,3,4,7,8-HxCDD	<38	45
1,2,3,6,7,8-HxCDD	190	210
1,2,3,7,8,9-HxCDD	<110	110
HpCDDs (total)	5,200	6,000
1,2,3,4,6,7,8-HpCDD	2,800	3,300
OCDD	11,000	12,000
TPH (mg/ml)		
JP-4	240	250

(a) Based on the QCSR for the Phase II OU 1 RI, this datum has been qualified and is not considered representative of the environment.

g 2,3,7,8-TCDF results were confirmed on DB-225 column

< Not detected at or above the specified detection limit

J Value is an estimated concentration below the practical quantitation limit



EXPLANATION

LNAPL thickness

Ground-water elevation

HILL AIR FORCE BASE
OPERABLE UNIT 1
LNAPL THICKNESS vs. GROUND-WATER ELEVATION
FOR WELLS U1-072, U1-074, AND U1-101
FIGURE 7-10

PROJECT NO. 2208.0991

WELL UI-101 IS IN THIS AREA

TABLE 6-10

RANGE OF ANALYTICAL RESULTS FOR SOIL SAMPLES COLLECTED AT FIRE TRAINING AREA 1

Analyte (Units)	General Compound Type	Range of Concentrations Detected	Number of Detections per Analyses
Volatile Organic Compounds (µg/kg)			
1,1,1-Trichloroethane	Chlorinated Hydrocarbon	1.4	1 of 13
1,2,4-Trichlorobenzene	Chlorinated Hydrocarbon	41,000	1 of 13
1,2-Dichlorobenzene	Chlorinated Hydrocarbon	15,000	1 of 13
1,3-Dichlorobenzene	Chlorinated Hydrocarbon	520 J	1 of 13
1,4-Dichlorobenzene	Chlorinated Hydrocarbon	2,600 J	1 of 13
Acetone	Organic Solvent of Lab Contaminant	7.1 to 3,200[a]	10 of 13
Acrylonitrile	Lab Contaminant	3.400 to 10.000[a]	2 of 13
Chlorobenzene	Chlorinated Hydrocarbon	17	1 of 13
Ethylbenzene	Fuel Hydrocarbon	59 to 3,500	6 of 13
Methylene Chloride	Chlorinated Hydrocarbon or Lab Contaminant	1.7 to 4.4[a]	3 of 13
Naphthalene	Fuel Hydrocarbon	340 to 9,900	5 of 12
Tetrachloroethene (PCE)	Chlorinated Hydrocarbon	11	1 of 13
Toluene	Fuel Hydrocarbon	0.77 J[a]	1 of 13
Total 1,2-Dichloroethene	Chlorinated Hydrocarbon	2.2	1 of 13
Trichloroethene (TCE)	Chlorinated Hydrocarbon	2.2 J	1 of 13
Xylenes, Total	Fuel Hydrocarbon	1.9 to 37,000	8 of 13
BNAEs (µg/kg)			
Benzoic Acid	Fuel Hydrocarbon	190 J	1 of 13
2-Methylnaphthalene	Fuel Hydrocarbon	4,200 to 7,700	3 of 13
Acenaphthene	Fuel Hydrocarbon	130 J to 270 J	2 of 13
Fluorene	Fuel Hydrocarbon	360 to 930	2 of 13
Phenanthrene	Fuel Hydrocarbon	450 to 1400	2 of 13
Anthracene	Fuel Hydrocarbon	240 J	1 0f 13
Di-n-Butyl Phthalate	Ubiquitous Plasticizer	260 J	1 of 13
Fluoranthene	Fuel Hydrocarbon	65 J	1 of 13
Pyrene	Fuel Hydrocarbon	100 J to 290 J	2 of 13
4-Aminobiphenyl	Amine	210 J to 1000	2 of 13
Total Petroleum Hydrocarbons (mg/kg)			
Jet Fuel #4	Fuel Hydrocarbon	270 to 3,200	7 of 13
Pesticides and PCBs (mg/kg)			
p,p'-DDE	Pesticide	0.0048 to 0.0065	2 of 5
p,p'-DDD	Pesticide	0.0042	1 of 5
p,p'-DDT	Pesticide	0.0048 to 0.33	2 of 5
PCB-1260 (Arochlor 1260)	PCB	0.072 to 5	2 of 5

(a) These data have been qualified and are not considered to be representative of the environment. See the Final QCSR for the Phase II Operable Unit 1 Remedial Investigation (Montgomery Watson, 1994) for a detailed discussion.

J indicates an estimated concentration.

TABLE 6-10

RANGE OF ANALYTICAL RESULTS FOR SOIL SAMPLES COLLECTED AT FIRE TRAINING AREA 1

Analyte (Units)	General Compound Type	Range of Concentrations Detected	Number of Detections per Analyses
Dioxin/Furans (pg/g)			
Tetrachlorinated Dibenzofurans, (Total)	Furan	17 to 1,600	5 of 5
2,3,7,8-Tetrachlorodibenzofuran	Furan	1.6 to 37	4 of 5
Pentachlorinated Dibenzofurans, (Total)	Furan	21 to 1,100	5 of 5
1,2,3,7,8-Pentachlorodibenzofuran	Furan	51	1 of 5
2,3,4,7,8-Pentachlorodibenzofuran	Furan	5 to 100	3 of 5
Hexachlorinated Dibenzofurans, (Total)	Furan	13 to 580	5 of 5
1,2,3,4,7,8-Hexachlorodibenzofuran	Furan	9.7 to 75	3 of 5
1,2,3,6,7,8-Hexachlorodibenzofuran	Furan	6.3 to 50	3 of 5
2,3,4,6,7,8-Hexachlorodibenzofuran	Furan	6 to 71	3 of 5
1,2,3,7,8,9-Hexachlorodibenzofuran	Furan	16	1 of 5
Heptachlorinated Dibenzofurans, (Total)	Furan	11 to 850	5 of 5
1,2,3,4,6,7,8-Heptachlorodibenzofuran	Furan	8.1 to 350	4 of 5
1,2,3,4,7,8,9-Heptachlorodibenzofuran	Furan	7.4 to 22	2 of 5
Octachlorodibenzofuran	Furan	12 to 400	4 of 5
Tetrachlorinated Dibenzo-p-Dioxins, (Total)	Dioxin	11 to 250	4 of 5
2,3,7,8-Tetrachlorodibenzo-p-Dioxin	Dioxin	7 to 13	3 of 5
Pentachlorinated Dibenzo-p-Dioxins, (Total)	Dioxin	11 to 390	4 of 5
1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	Dioxin	25 to 42	3 of 5
Hexachlorinated Dibenzo-p-Dioxins, (Total)	Dioxin	34 to 1,800	4 of 5
1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	Dioxin	22 to 50	3 of 5
1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	Dioxin	56 to 220	3 of 5
1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	Dioxin	35 to 120	3 of 5
Heptachlorinated Dibenzo-p-Dioxins, (Total)	Dioxin	21 to 5,700	5 of 5
1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	Dioxin	11 to 3,000	5 of 5
Octachlorodibenzo-p-Dioxin	Dioxin	83 to 15,000	5 of 5
Metals (µg/g)			
Arsenic	Metal	0.7 to 4.6	13 of 13
Beryllium	Metal	1	1 of 13
Cadmium	Metal	3 to 6	3 of 13
Chromium	Metal	4 to 52	13 of 13
Copper	Metal	2 to 120	13 of 13
Lead	Metal	2 to 150	8 of 13
Mercury	Metal	0.06 to 0.12	3 of 13
Zinc	Metal	10 to 96	13 of 13

(a) These data have been qualified and are not considered to be representative of the environment. See the Final QCSR for the Phase II Operable Unit 1 Remedial Investigation (Montgomery Watson, 1994) for a detailed discussion.

J indicates an estimated concentration.

TABLE 6-15

SUMMARY OF CONTAMINANT AREA, VOLUME, AND MASS FOR FIRE TRAINING AREA 1

Depth Interval (ft bgs)	Concentration Range (mg/kg)	Median Concentration (mg/kg)	Area of Contamination (sq ft)	Volume of Contamination (cubic yards)	Mass of TPH (kg)
0 to 5	100 to 500	300	0	0	0
	501 to 1,000	750	0	0	0
	>1,000	1,000	0	0	0
			0	0	0
5 to 15	100 to 500	300	2,510	930	4,140
	501 to 1,000	750	1,730	640	7,140
	>1,000	2,000	670	250	7,370
			4,910	1,820	18,650
15 to 25	100 to 500	300	7,550	2,800	12,460
	501 to 1,000	750	4,990	1,850	20,580
	>1,000	1,000	0	0	0
			12,540	4,650	33,040
25 to 29	100 to 500	300	6,960	1,030	4,590
	501 to 1,000	750	10,300	1,530	17,000
	>1,000	2,100	2,220	330	10,260
			19,480	2,890	31,850
			Grand Total	9,360	83,540

RADIAN CORPORATION

LOG OF DRILLING OPERATIONS

Boring or Well No. M-31 (U1-069)
Location Chemical Pit No.1 and 2
Log Recorded by Leslie Campbell
Type Drill Rig and Operator HSA-Dave's Drilling
Ground Level Elevation 4799.84 ft. MSL

Project Hill AFB IRP Phase II Stage 2
Beginning 28 May 1986 and end 29 May 1986 of drilling operation
Sampling Interval (Est.) 5 ft

Depth	Sample Method	ID No. of Sample Taken	Graphic Log	Lithologic Description	Remarks
	C			SAND: Red-brown; fine- to medium-grained; minor gravel; unconsolidated; moist.	poly=neg.
5					
10					
15					
20	SS			Dark brown; medium- to coarse-grained; gravelly; wet.	poly=pos.
25	SS			Black.	poly=pos.
30	SS			Dark brown.	poly=pos.
35	SS			CLAY: Dark red-brown; silty; fine-grained sand stringers; cohesive; moist.	poly=pos. Total Depth= 35.5 ft.
40					
45					

[redacted]

U1-069 / M-31

TEST WELL COMPLETION DATA
HILL AIR FORCE BASE INSTALLATION RESTORATION PROGRAM

Draft Field Form: Radian/SAIC Test Well/Hole Completion

TEST WELL/HOLE NO. (U1 - 069)	M-31
Location	Chemical Pits No.1 and 2
Geologist	Leslie Campbell
Drilled by	Dave's Drilling
Elevation (Surface)	4799.89 ft. MSL
Elevation Measuring Point (MP)	4801.08 ft. MSL
CONSTRUCTION	
Start Date	5/28/86
Completion Date	5/29/86
Drilling Method	Hollow Stem Auger
Depth Drilled (ft.)	33.1 ft.
Hole Diameter (in.)	8 in.
Water Source	Base Potable
COMPLETION	
Completion Type	Above Ground Level
Blank Casing 2" PVC	+3-14.5 ft.
Schedule	40
Blank Stainless Steel 2"	-
Stainless Steel Screen 2"	14.5-31.0 ft.
Slot Size (in.)	0.02
Grout	0-8.5 ft.
No. of sacks	5
Bentonite	8.5-11.0 ft.
Amount (gal.)	5
Sand Pack	11.0-14.5 ft.
Type	Colorado Silica
Size	10-20
Amount (gal.)	40
Water Level (ft.) below MP	25.58 ft.
Date	8/14/86
Depth inside Well (ft.) below MP	33.37 ft.
Comment(s)/Problems	-
FORMATION SAMPLING	
Sampling Type	Cuttings, Split Spoon
Sampling Total Depth (ft.)	35 ft.
Number of Samples	8

TABLE 7-3

SUMMARY OF VOC, BNAE, PESTICIDE/PCB, DIOXIN/FURAN, AND TPH RESULTS FOR LNAPL SAMPLES COLLECTED DOWNGRADIENT OF THE CHEMICAL DISPOSAL PITS DURING THE PHASE II RI

Analytes / Sample Location:	Results U1-065	Results U1-004
VOCs (µg/kg)		
Acetone	1,100,000(a)	<43,000
Total 1,2-dichloroethene	<52,500	87,000
1,1,1-Trichloroethane	<27,500	92,000
Tetrachloroethene	<35,000	38,000
Toluene	<35,000	770,000
Chlorobenzene	2,300,000	<13,000
Ethylbenzene	<27,500	210,000
Total xylene	<23,250	1,400,000
BNAEs (µg/kg)		
1,2-Dichlorobenzene	<400,000	2,700,000
Naphthalene	430,000	640,000
2-Methylnaphthalene	<400,000	810,000
bis(2-Ethylhexyl) phthalate	<400,000	730,000(a)
Pesticides/PCBs (µg/ml)		
Aldrin	<0.05	0.41
Alpha-BHC	<0.05	0.15
Dieldrin	<0.05	0.35
Endosulfan Sulfate	3.5	5.3
Endrin	<0.25	0.73
Heptachlor	0.12	0.13
Heptachlor Epoxide	0.41	0.45
PCB-1260	230	190
Dioxin/Furans		
Furans (pg/ml)		
TCDFs (total)	3,800	320
2,3,7,8-TCDF	940 g	11 g

U1-069 IS IN THE IMMEDIATE VICINITY OF THESE TWO WELLS.

(a) Based on QCSR for the Phase II OU 1 RI, the datum has been qualified and is not considered representative of the environment

g 2,3,7,8-TCDF results confirmed on DB-225 column

√ Value is an estimated concentration below the practical quantitation limit

< Not detected at or above the specified detection limit

µg/kg Microgram per kilogram
mg/ml Milligram per milliliter
µg/ml Microgram per milliliter
pg/ml Picogram per milliliter

TABLE 7-3

SUMMARY OF VOC, BNAE, PESTICIDE/PCB, DIOXIN/FURAN, AND TPH RESULTS FOR LNAPL SAMPLES COLLECTED DOWNGRADIENT OF THE CHEMICAL DISPOSAL PITS DURING THE PHASE II RI (CONTINUED)

Analytes	Sample Location:	Results U1-065	Results U1-004
Furans (pg/ml) (continued)			
PeCDFs (total)		44,000	350
1,2,3,7,8-PeCDF		1,200	<11
2,3,4,7,8-PeCDF		3,000	32 √
HxCDFs (total)		50,000	370
1,2,3,4,7,8-HxCDF		8,900	86
1,2,3,6,7,8-HxCDF		3,700	37 √
2,3,4,6,8-HxCDF		3,200	32
1,2,3,7,8,9-HxCDF		1,400	<13
HpCDFs (total)		32,000	290
1,2,3,4,6,7,8-HpCDF		22,000	200
1,2,3,4,7,8,9-HpCDF		1,800	29 √
OCDF		11,000	220
Dioxins (pg/ml)			
TCDDs (total)		8,300	16
2,3,7,8-TCDD		110	<2.3
PeCDDs (total)		14,000	57
1,2,3,7,8-PeCDD		550	<3.3
HxCDDs (total)		23,000	86
1,2,3,4,7,8-HxCDD		560	<4.10
1,2,3,6,7,8-HxCDD		2,700	<18
1,2,3,7,8,9-HxCDD		1,300	<8.2
HpCDDs (total)		49,000	320
1,2,3,4,6,7,8-HpCDD		29,000	180
OCDD		63,000	630
TPH (mg/ml)			
JP-4		120	72

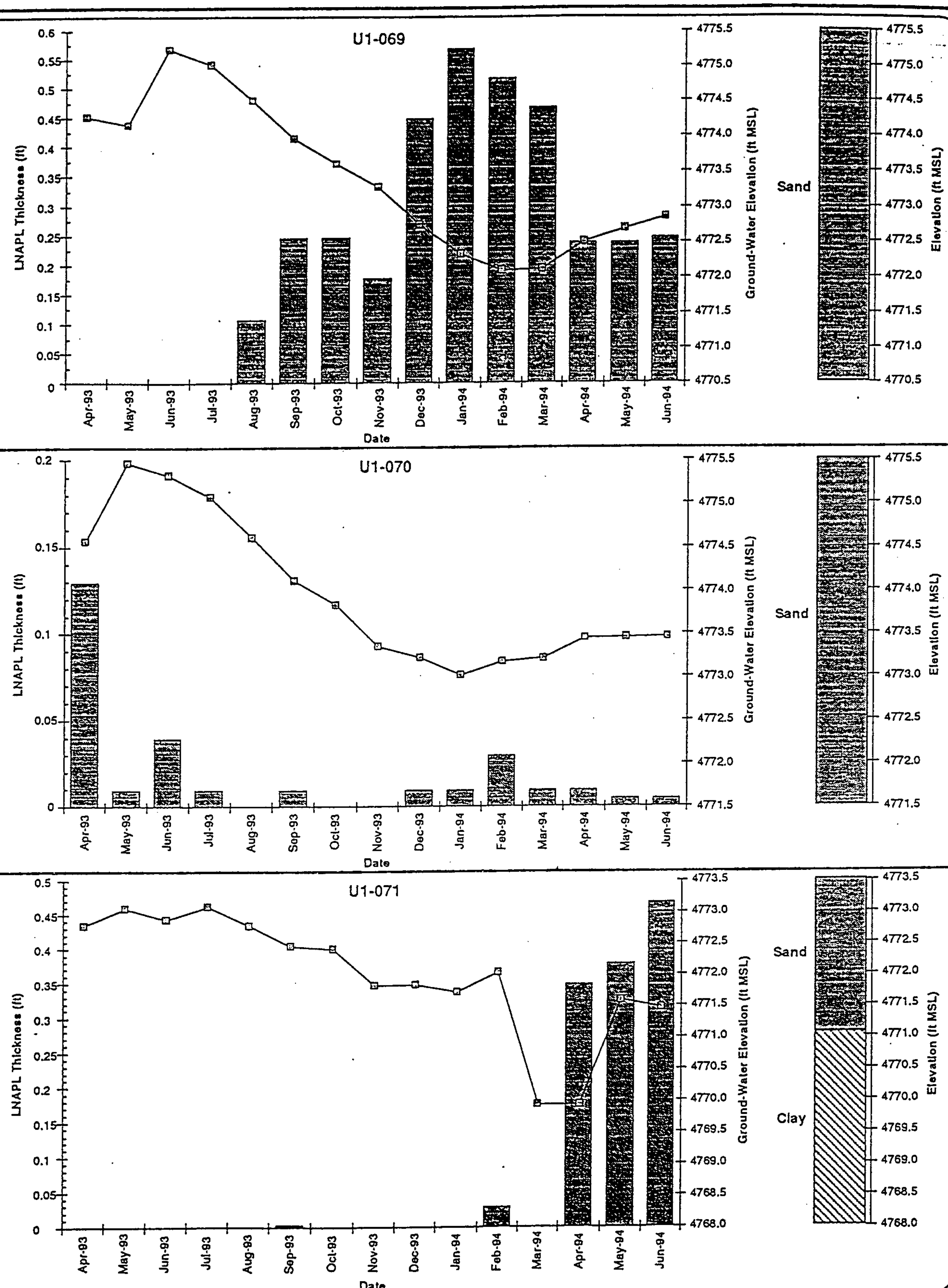
(a) Based on QCSR for the Phase II OU 1 RI, the datum has been qualified and is not considered representative of the environment

g 2,3,7,8-TCDF results confirmed on DB-225 column

√ Value is an estimated concentration below the practical quantitation limit

< Not detected at or above the specified detection limit

µg/kg Microgram per kilogram
mg/ml Milligram per milliliter
µg/ml Microgram per milliliter
pg/ml Picogram per milliliter



EXPLANATION

LNAPL thickness

Ground-water elevation

HILL AIR FORCE BASE

OPERABLE UNIT 1

LNAPL THICKNESS vs. GROUND-WATER ELEVATION FOR WELLS U1-069, U1-070, AND, U1-071

FIGURE 7-9

PROJECT NO. 2208.0991

WELL U1-069 IS LOCATED IN THIS AREA

TABLE 6-6

RANGE OF ANALYTICAL RESULTS FOR SOIL SAMPLES
COLLECTED AT CDPs 1 and 2

Analyte (Units)	General Compound Type	Range of Concentrations Detected	Number of Detections per Analyses
Volatile Organic Compounds (µg/kg)			
1,1,1-Trichloroethane	Chlorinated Hydrocarbon	1.3 to 8,100	37 of 88
1,1-Dichloroethane	Chlorinated Hydrocarbon	1.2 to 230	8 of 88
1,1-Dichloroethene	Chlorinated Hydrocarbon	34 to 790	3 of 88
1,2,3-Trichlorobenzene	Chlorinated Hydrocarbon	0.99 to 2,900	6 of 32
1,2,4-Trichlorobenzene	Chlorinated Hydrocarbon	0.06 to 19,000	34 of 88
1,2,4-Trimethylbenzene	Fuel Hydrocarbon	0.66 to 54,000	21 of 32
1,2-Dichlorobenzene	Chlorinated Hydrocarbon	1.9 to 170,000	42 of 88
1,2-Dichloroethane	Chlorinated Hydrocarbon	2.9 to 64	4 of 88
1,3,5-Trimethylbenzene (Mesitylene)	Fuel Hydrocarbon	0.89 to 20,000	20 of 32
1,3-Dichlorobenzene	Chlorinated Hydrocarbon	1.0 to 3,200	13 of 85
1,4-Dichlorobenzene	Chlorinated Hydrocarbon	2.4 to 21,000	37 of 86
2-Butanone (MEK)	Organic Solvent or Lab Contaminant	1,800 to 5,200(a)	10 of 56
2-Hexanone	Organic Solvent	8,000	1 of 56
Acetone	Organic Solvent or Lab Contaminant	7.3 to 1,400(b)	22 of 56
Benzene	Fuel Hydrocarbon	1.3 to 140 J	4 of 88
Chlorobenzene	Chlorinated Hydrocarbon	37 to 2,000	9 of 88
Chloroform	Chlorinated Hydrocarbon	120 J	1 of 88
Ethylbenzene	Fuel Hydrocarbon	1.2 to 6,200	27 of 88
Isopropylbenzene (Cumene)	Fuel Hydrocarbon	7.1 to 1,200	5 of 32
Methyl Isobutyl Ketone	Organic Solvent	4.8 to 6.5	2 of 45
Methylene Chloride	Chlorinated Hydrocarbon or Lab Contaminant	1.2 to 670(b)	12 of 88
Naphthalene	Fuel Hydrocarbon	42 to 17,000	33 of 88
Styrene	Fuel Hydrocarbon	1.5	1 of 88
Tetrachloroethene (PCE)	Chlorinated Hydrocarbon	1.8 to 9,100	37 of 88
Toluene	Fuel Hydrocarbon	0.92 to 57,000	49 of 88
Total 1,2-Dichloroethene	Chlorinated Hydrocarbon	3.9 to 14,000	13 of 56
Trichloroethene (TCE)	Chlorinated Hydrocarbon	1.9 to 40,000	28 of 88
Xylenes, Total	Fuel Hydrocarbon	8.3 to 51,000	20 of 56
cis-1,2-Dichloroethene	Chlorinated Hydrocarbon	3.6 to 4,200	19 of 32
m,p-Xylene	Fuel Hydrocarbon	5.5 to 30,000	19 of 32
n-Propylbenzene	Fuel Hydrocarbon	770 to 6,000	8 of 32
o-Xylene (1,2-Dimethylbenzene)	Fuel Hydrocarbon	15 to 12,000	18 of 32
p-Cymene (p-Isopropyltoluene)	Fuel Hydrocarbon	35 to 4,500	11 of 32
sec-Butylbenzene	Fuel Hydrocarbon	6.7 to 4,100	8 of 32

(a) Introduced into sample during analyses (Datachem, 1992)

(b) These data have been qualified and are not considered to be representative of the environment. See the Final QCSR for Operable Unit 1 (Montgomery Watson, 1994) and the Final QCSR for the Phase II Operable Unit 1 Remedial Investigation (Montgomery Watson, 1994) for a detailed discussion.

J indicates an estimated concentration.

TABLE 6-6

RANGE OF ANALYTICAL RESULTS FOR SOIL SAMPLES
COLLECTED AT CDPs 1 and 2

Analyte (Units)	General Compound Type	Range of Concentrations Detected	Number of Detections per Analyses
BNAEs (µg/kg)			
Aniline	Laquer/Wood Stain	1,000	1 of 56
Phenol	Phenol	1,200 J	1 of 54
4-Methylphenol (P-Cresol)	Phenol	30 J	1 of 56
2,4-Dimethylphenol	Phenol	3,500	1 of 55
2-Methylnaphthalene	Fuel Hydrocarbon	1,200 to 17,000	18 of 56
Diethylphthalate	Ubiquitous Plasticizer	20 J	1 of 56
Fluorene	Fuel Hydrocarbon	250 J to 1,400 J	5 of 56
Phenanthrene	Fuel Hydrocarbon	30 J to 1,800	7 of 55
Anthracene	Fuel Hydrocarbon	220 J	1 of 55
Di-n-Butyl Phthalate	Ubiquitous Plasticizer	30 J to 190 J	8 of 56
Fluoranthene	Fuel Hydrocarbon	50 J to 200 J	7 of 55
Pyrene	Fuel Hydrocarbon	30 J to 810 J	11 of 54
Benzyl Butyl Phthalate	Ubiquitous Plasticizer	40 J to 130 J	2 of 56
Benzo(a)Anthracene	Fuel Hydrocarbon	60 J to 80 J	2 of 56
Chrysene	Fuel Hydrocarbon	70 J to 380 J	5 of 56
Bis(2-Ethylhexyl) Phthalate	Ubiquitous Plasticizer or Lab Contaminant	20 J to 14,000(b)	30 of 56
Di-n-Octyl Phthalate	Ubiquitous Plasticizer	60 J	1 of 56
Benzo(a)Pyrene	Fuel Hydrocarbon	40 J to 540 J	3 of 56
Total Petroleum Hydrocarbons (mg/kg)			
Jet Fuel #4	Fuel Hydrocarbon	500 to 42,100	14 of 88
Jet Fuel #8	Fuel Hydrocarbon	2,700 to 8,600	5 of 77
Petroleum Hydrocarbons	Fuel Hydrocarbon	14 to 16,000	26 of 32
Gasoline Components	Fuel Hydrocarbon	1.4 to 2,200	23 of 77
Pesticides and PCBs (mg/kg)			
Alpha BHC	Pesticide	0.006 to 0.007	2 of 12
Delta BHC	Pesticide	0.007 to 0.02	2 of 12
Aldrin	Pesticide	0.003 to 0.02	6 of 12
Dieldrin	Pesticide	0.007 to 0.015	4 of 12
p,p'-DDE	Pesticide	0.006 to 0.053	4 of 12
Endrin	Pesticide	0.005 to 0.073	5 of 12
Beta Endosulfan	Pesticide	0.005 to 0.2	3 of 12
p,p'-DDD	Pesticide	0.009 to 0.37	6 of 12
p,p'-DDT	Pesticide	0.035 to 0.46	2 of 12
Methoxychlor	Pesticide	0.087 to 1.2	3 of 12
Endrin Aldehyde	Pesticide	0.14	1 of 12

(a) Introduced into sample during analyses (Datachem, 1992)

(b) These data have been qualified and are not considered to be representative of the environment. See the Final QCSR for Operable Unit 1 (Montgomery Watson, 1994) and the Final QCSR for the Phase II Operable Unit 1 Remedial Investigation (Montgomery Watson, 1994) for a detailed discussion.

J indicates an estimated concentration.

TABLE 6-6

RANGE OF ANALYTICAL RESULTS FOR SOIL SAMPLES
COLLECTED AT CDPs 1 and 2
(3 of 3)

Analyte (Units)	General Compound Type	Range of Concentrations Detected	Number of Detections per Analyses
Pesticides and PCBs (mg/kg) <continued>			
Alpha-Chlordane	Pesticide	0.005 to 0.016	3 of 8
PCB-1016 (Arochlor 1016)	PCB	0.15 to 0.29	3 of 12
PCB-1260 (Arochlor 1260)	PCB	0.07 to 8.3	10 of 12
Dioxin/Furans (pg/g)			
Tetrachlorinated Dibenzofurans, (Total)	Furan	1.5 to 190	5 of 5
2,3,7,8-Tetrachlorodibenzofuran	Furan	1.4 to 8.3	3 of 5
Pentachlorinated Dibenzofurans, (Total)	Furan	57 to 190	3 of 5
1,2,3,7,8-Pentachlorodibenzofuran	Furan	7.8 to 8.4	2 of 5
2,3,4,7,8-Pentachlorodibenzofuran	Furan	5.6 to 20	3 of 5
Hexachlorinated Dibenzofurans, (Total)	Furan	26 to 210	4 of 5
1,2,3,4,7,8-Hexachlorodibenzofuran	Furan	22 to 55	3 of 5
1,2,3,6,7,8-Hexachlorodibenzofuran	Furan	6.2 to 16	3 of 5
2,3,4,6,7,8-Hexachlorodibenzofuran	Furan	5.6 to 20	3 of 5
1,2,3,7,8,9-Hexachlorodibenzofuran	Furan	6 to 8.1	2 of 5
Heptachlorinated Dibenzofurans, (Total)	Furan	13 to 370	5 of 5
1,2,3,4,6,7,8-Heptachlorodibenzofuran	Furan	30 to 140	4 of 5
1,2,3,4,7,8,9-Heptachlorodibenzofuran	Furan	13 to 26	3 of 5
Octachlorodibenzofuran	Furan	17 to 310	5 of 5
Tetrachlorinated Dibenzo-p-Dioxins, (Total)	Dioxin	3.6 to 40	4 of 5
Pentachlorinated Dibenzo-p-Dioxins, (Total)	Dioxin	18 to 39	3 of 5
Hexachlorinated Dibenzo-p-Dioxins, (Total)	Dioxin	14 to 150	4 of 5
1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	Dioxin	7.1	1 of 5
1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	Dioxin	7.5 to 20	2 of 5
1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	Dioxin	5.1 to 16	2 of 5
Heptachlorinated Dibenzo-p-Dioxins, (Total)	Dioxin	29 to 840	5 of 5
1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	Dioxin	15 to 480	5 of 5
Octachlorodibenzo-p-Dioxin	Dioxin	45 to 3,500	5 of 5
Metals (µg/g)			
Arsenic	Metal	0.8 to 6.6	56 of 56
Cadmium	Metal	2 to 3	2 of 50
Chromium	Metal	5 to 62	50 of 50
Copper	Metal	2 to 200	50 of 50
Lead	Metal	1 to 860	45 of 50
Mercury	Metal	0.05 to 0.3	2 of 56
Zinc	Metal	9 to 79	50 of 50

(a) Introduced into sample during analyses (Datachem, 1992)

(b) These data have been qualified and are not considered to be representative of the environment. See the Final QCSR for Operable Unit 1 (Montgomery Watson, 1994) and the Final QCSR for the Phase II Operable Unit 1 Remedial Investigation (Montgomery Watson, 1994) for a detailed discussion.

J indicates an estimated concentration.

TABLE 6-14

SUMMARY OF CONTAMINANT AREA, VOLUME, AND MASS FOR THE CHEMICAL DISPOSAL PITS

Depth Interval (ft bgs)	Concentration Range (mg/kg)	Median Concentration (mg/kg)	Area of Contamination (sq ft)	Volume of Contamination (cubic yards)	Mass of TPH (kg)
0 to 5	1 to 50	25	1,070	200	70
	51 to 100	75	1,160	210	240
	101 to 500	300	110	20	90
	501 to 1,000	750	0	0	0
	1,001 to 5,000	3,000	0	0	0
	> 5,000	5,000	0	0	0
			2,340	430	400
5 to 13	1 to 50	25	3,130	930	340
	51 to 100	75	2,900	860	960
	101 to 500	300	3,740	1,110	4,940
	501 to 1,000	750	9,050	2,680	29,860
	1,001 to 5,000	3,000	380	110	5,020
	> 5,000	5,000	0	0	0
			19,200	5,690	41,120
13 to 23	1 to 50	25	5,650	2,090	780
	51 to 100	75	6,410	2,370	2,640
	101 to 500	300	8,380	3,100	13,830
	501 to 1,000	750	9,030	3,340	37,250
	1,001 to 5,000	3,000	27,020	10,010	445,830
	> 5,000	6,550	7,190	2,660	259,020
			63,680	23,570	759,350
23 to 31	1 to 50	25	8,540	2,530	940
	51 to 100	75	13,900	4,120	4,590
	101 to 500	300	7,210	2,140	9,520
	501 to 1,000	750	6,710	1,990	22,140
	1,001 to 5,000	3,000	3,920	1,160	51,740
	> 5,000	23,550	1,600	470	165,790
			41,880	12,410	254,720
			Grand Total	42,100	1,055,590

APPENDIX B

LABORATORY ANALYTICAL REPORTS

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

Boise, Idaho
(208) 336-4145

Las Vegas, Nevada
(702) 386-6747

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: 90106
Phone: (614) 424-6199
Attn: Al Pollock

Sampled: 10/27/95 Received: 10/31/95 Analyzed: 11/02-04/95

Matrix: [X] Soil [ ] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Extractable Quantitated As Diesel
BTXE - Benzene, Toluene, Xylenes, Ethylbenzene

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTXE - EPA Method 624/8240

TPH/BTXE Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
HAFB-BW-22.0'- 22.5' BMI103195-01	TPH *	1,800	200	mg/Kg
	Benzene	ND	1,000	ug/Kg
	Toluene	ND	1,000	ug/Kg
	Total Xylenes	ND	1,000	ug/Kg
	Ethylbenzene	ND	1,000	ug/Kg
HAFB-BW-25.5'- 26.0' BMI103195-02	TPH **	3,500	200	mg/Kg
	Benzene	ND	1,000	ug/Kg
	Toluene	ND	1,000	ug/Kg
	Total Xylenes	ND	1,000	ug/Kg
	Ethylbenzene	ND	1,000	ug/Kg

* - Components are primarily in the range of jet fuel, kerosene and diesel #1 with minor amounts of light oil and motor oil.

** - Components are primarily in the range of jet fuel, kerosene and diesel #1 with minor amounts of diesel #2, light oil and motor oil.

Note: Hydrocarbons outside the range of diesel may have varying recoveries.

ND - Not Detected

Approved By: Roger L. Scholl Date: 11/15/95
Roger L. Scholl, Ph.D.
Laboratory Director

Laboratory Analysis Report

Sierra Environmental Monitoring, Inc.

ALPHA ANALYTICAL
255 GLENDALE AVENUE, SUITE 21
SPARKS NV 89431

Date : 11/15/95
Client : ALP-855
Taken by: CLIENT
Report : 14817
PO# :

Sample	Collected Date	Collected Time	MOISTURE CONTENT %	PARTICLE SIZE CLASSIF. HYDROMETER	DENSITY G/CM3	POROSITY %		
BMI103195-03 - HAFB-BW-23-24	10/27/95	:	3.8	YES	1.11	58.1		
BMI103195-04 - HAFB-BW-25-25.5	10/27/95	:	4.8	YES	1.09	58.8		

Approved By: [signature]

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

William F. Pillsbury
President

John C. Seher
Manager

Sierra
Environmental
Monitoring, Inc.

November 14, 1995

TO: **Alpha Analytical**

FROM: Sierra Environmental Monitoring, Inc.

RE: Particle Size Distribution Analysis for Samples:

SEM 9510-0907 AAI BMI103195-03
SEM 9502-0908 AAI BMI103195-04

As per your request, we have performed particle size analysis on the samples submitted to our laboratory. Test results are as follows:

	9510-0907	9510-0908
% Sand	58.6	63.1
% Silt	25.6	18.3
% Clay	15.8	18.6

The sample was passed through a #10 sieve prior to analysis as per procedure. All results are based on oven dry sample weights.

We appreciate this opportunity to provide our laboratory testing services. If you have any questions or require further testing, please feel free to contact us at your convenience.

Sincerely,
SIERRA ENVIRONMENTAL MONITORING, INC.

John Seher
Laboratory Manager

William F. Pillsbury
President

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

John C. Seher
Manager

PO 9700 (partly obscured)

Battelle Columbus Laboratories

ATTN. Randy Gardner

CHAIN OF CUSTODY RECORD

Form No. 001

Proj. No. G462201-30C07U

Project Title Bioslurper HILL AFB

SAMPLERS: (Signature) Greg Headington

DATE	TIME	SAMPLE I.D.	Diesel BTEX/TPH	Particle Size	Bulk Density	Porosity	Moisture Content	Container No.	Number of Containers	Remarks (Heavy oil/fuel type)
27OCT95		HAFB-BW-22.0'-22.5'	X						1	Call Al Pollack for method
27OCT95		HAFB-BW-25.5'-26.0'	X						1	
27OCT95		HAFB-BW-23.0'-24.0'		X	X	X	X		2	2 sleeves
27 OCT 95		HAFB-BW-25.0'-25.5'		X	X	X	X		1	
~~27 OCT 95~~										

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Greg Headington	30OCT95 0800				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
		[signature]	10/31/95 1000	Results to AL Pollack, Battelle (614) 424-3753	

Page 1 of 1

[redacted] Billing [redacted]:

Name

Address

City, State, Zip

Phone Number

Alpha [redacted], Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Page # 1 of 1

Client Name: Dattelle

P.O. #: 90106

Address:

Phone #: (714) 424-3753

City, State, Zip:

Report Attention: Al Pollack

Sampled by: Client

Analyses Required

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	TPH	BTXE	Particle Size	Bulk Density	Porosity	Moisture Content				Remarks
	10/27	SO	BMI 103195-01	HAFB-BW-22.0'-22.5'	1	X	X								Heavy oil Fuel type
	✓	✓	02	" -BW-25.5-26.0'	1	X	X								" " " "
	✓	✓	03	" -BW-23.0'-24.0'	2			X	X	X	X				Composite together
	✓	✓	04	" -BW-25.0-25.5'	1			X	X	X	X				

[illegible]

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	[signature]	Linda Bldark	ANZ	10/31/95	1000
Relinquished by					
Received by			Sem	10/31/95	1445
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

Boise, Idaho
(208) 336-4145

Las Vegas, Nevada
(702) 386-6747

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#:
Phone: (614) 424-6199
Attn: Al Pollock

Sampled: 10/30-11/02/95 Received: 11/06/95 Analyzed: 11/09-10/95

Matrix: [ ] Soil [X] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Extractable Quantitated As Diesel
BTXE - Benzene,Toluene,Xylenes,Ethylbenzene

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTXE - EPA Method 624/8240

TPH/BTXE Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
HAFB-OWS-1 /BMI110695-01	TPH *	180	5.0	mg/L
	Benzene	ND	5.0	ug/L
	Toluene	ND	5.0	ug/L
	Total Xylenes	38	5.0	ug/L
	Ethylbenzene	ND	5.0	ug/L
HAFB-Baker-1 /BMI110695-02	TPH *	7.4	5.0	mg/L
	Benzene	1.7	1.0	ug/L
	Toluene	0.57	1.0	ug/L
	Total Xylenes	15	1.0	ug/L
	Ethylbenzene	1.9	1.0	ug/L

* - Components are in the range of jet fuel, diesel, light oil and motor oil.

Note: Hydrocarbons outside the range of diesel may have varying recoveries.

ND - Not Detected

Approved By: Roger L. Scholl Date: 11/15/95
Roger L. Scholl, Ph.D.
Laboratory Director

Battelle
Columbus Laboratories

Form No. ______

CHAIN OF CUSTODY RECORD

Proj. No. G402:01 3000701

Project Title Bioslurper Hill AFB

SAMPLERS: (Signature) ~~Rick Gillespie~~ Rick Gillespie

DATE	TIME	SAMPLE I.D.	SAMPLE TYPE (√): TPH	BTEX											Container No.	Number of Containers	Remarks
30Oct95	1450	HAFB-OWS-1	√	√												2	Heavy fuel/oil:
2Nov95	1500	HAFB Blank 1		√													Contact Al [illegible]
																	for supplemental

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Rick Gillespie	2Nov95 1700				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
		[signature]	11/6/95 1030	Please send all results to Al Pollack: 614-424-3657

Page ______ of ______

Billing [redacted]mation:

Name
Address
City, State, Zip
Phone Number

Alph[redacted]al, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Page # 1 of 1

Client Name Dattilla		P.O. #
Address		Phone # (4?) A24-3657
City, State, Zip	Report Attention Al Pollock	

Sampled by client

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	TPH	BTEX								Remarks
	10/30	AK	BMI110695-01	HAFB-OWS-1	2	X	X								Heavy fuel oil
	11/2	✓	02	HAFB-Baker-1	2	X	X								VOAS only

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Bydairk	Linda Bydairk	~~Linda~~ / AAI	11/4/95	1030
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9511063

Work Order Summary

CLIENT: Mr. Eric Dreschler
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

BILL TO: Same

PHONE: 614-424-3753
FAX: 614-424-3667
DATE RECEIVED: 11/6/95
DATE COMPLETED: 11/15/95

INVOICE # 8658
P.O. # 268.01
PROJECT # G462201-30C0701 Bioslurper Hill AFB
AMOUNT$: $282.12

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	PRICE
01A	HAFB-OGS-STK1	TO-3	4.5 "Hg	$120.00
02A	HAFB-OGS-STK2	TO-3	3.5 "Hg	$120.00
03A	Lab Blank	TO-3	NA	NC

Misc. Charges	1 Liter Summa Canister Preparation (2) @ $10.00 each.	$20.00
	Shipping (10/23/95)	$22.12

CERTIFIED BY: Linda J. Freeman
Laboratory Director

DATE: 11/15/95

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA 95630
(916) 985-1000 • (800) 985-5955 • FAX (916) 985-1020

AIR TOXICS LTD.

SAMPLE NAME: HAFB-OGS-STK1

ID#: 9511063-01A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6110812		Date of Collection: 10/30/95	
Dil. Factor:	300		Date of Analysis: 11/8/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.30	0.97	5.2	17
Toluene	0.30	1.1	4.4	17
Ethyl Benzene	0.30	1.3	7.0	31
Total Xylenes	0.30	1.3	20 M	88 M

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name:	6110812		Date of Collection: 10/30/95	
Dil. Factor:	300		Date of Analysis: 11/8/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	3.0	19	6000	39000
C2 - C4** Hydrocarbons	3.0	5.5	61	110

*TPH referenced to Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

M = Reported value may be biased due to apparent matrix interferences.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: HAFB-OGS-STK2

ID#: 9511063-02A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6110813		Date of Collection: 11/2/95	
Dil. Factor:	140		Date of Analysis: 11/8/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.14	0.45	4.3	14
Toluene	0.14	0.54	3.2	12
Ethyl Benzene	0.14	0.62	3.6	16
Total Xylenes	0.14	0.62	7.9 M	35 M

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name:	6110813		Date of Collection: 11/2/95	
Dil. Factor:	140		Date of Analysis: 11/8/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	1.4	9.1	3800	25000
C2 - C4** Hydrocarbons	1.4	2.6	62	110

*TPH referenced to Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 9511063-03A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6110808		Date of Collection: NA	
Dil. Factor:	1.0		Date of Analysis: 11/8/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name:	6110808		Date of Collection: NA	
Dil. Factor:	1.0		Date of Analysis: 11/8/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	0.010	0.065	Not Detected	Not Detected
C2 - C4** Hydrocarbons	0.010	0.018	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA

AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

CHAIN-OF-CUSTODY RECORD

№ 008958

Contact Person: Al Pollack
Company: Battelle
Address: 505 King Avenue City: Columbus State: OH Zip: 43201
Phone: 614-424-3753 FAX: 614-424-3667
Collected By: Signature: Greg Headington / Rick Gillespie

Project info:
P.O. #: 91221
Project #: G462201-30C0701
Project Name: Bioslurper Hill AFB

Turn Around Time:
☒ Normal
☐ Rush ______ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
01A	HAFB-OGS-STK1	30 Oct 95 1420	TPH / BTEX as diesel	25 in Hg	0 in Hg	4.5"Hg
02A	HAFB-OGS-STK2	2Nov95/1500	TPH / BTEX as diesel	21" Hg	0" Hg	3.5"Hg 11/07-95

Relinquished By: (Signature) Date/Time	Print Name / Received By: (Signature) Date/Time
[signature] 2Nov95/1700	Rick Gillespie
Relinquished By: (Signature) Date/Time	Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time	Received By: (Signature) Date/Time: [signature] ATL 11/6/95 1000

Notes: Heavy oil/fuel : Call Al Pollack for method.

Lab Use Only

Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
Fed-X	4214047703	TS	11/6/95 1000	Ambient	Good	Yes No (None) N/A	9511063

Form 1293 rev. 06

APPENDIX C

SYSTEM CHECKLIST

Checklist for System Shakedown

Site: Hill AFB, OW01

Date: 10-27-95

Operator's Initials: RL

Equipment	Check if Okay	Comments
Liquid Ring Pump		Installed new re-circulation flow valve
Aqueous Effluent Transfer Pump	✓	
Oil/Water Separator	✓	
Vapor Flowmeter	✓	
Fuel Flowmeter	✓	
Water Flowmeter	✓	
Emergency Shut off Float Switch Effluent Transfer Tank		
Analytical Field Instrumentation GasTector™ O_2/CO_2 Analyzer TraceTector™ Hydrocarbon Analyzer Oil/Water Interface Probe Magnehelic Boards Thermocouple Thermometer	✓	

Figure 12. Bioslurper Pilot Test Shakedown Checklist

APPENDIX D

DATA SHEETS FROM THE SHORT-TERM PILOT TEST

Baildown Test Record Sheet

Site: Hill AFB

Well Identification: OW101

Well Diameter (OD/ID): 2" I.D.

Date at Start of Test: 27 Oct 95

Sampler's Initials: RG

Time at Start of Test: 1600

Initial Readings

Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (L)
28.97	28.37	0.6	.370 L

Test Data

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
1600	28.49'	28.44'	0.05'
1617	28.61'	28.43'	0.18'
1633	28.68'	28.43'	0.25'
1648	28.69'	28.42'	0.27'
1705	28.70'	28.43'	0.27'
1720	28.71'	28.42'	0.29'
1735	28.73'	28.42'	0.31'
1750	28.74'	28.42'	0.32'
1805	28.76'	28.42'	0.34'
28Oct95/0956	28.95'	28.39'	0.56'

Figure 9. Typical Baildown Test Record Sheet

Fuel and Water Recovery Data

Site: ~~Travis AFB~~ Hill AFB
Well ID: ~~Area G Wells~~ OU101
Test Type: ~~Vacuum Enhancement~~ Skimmer 48h

Start Date: 28 Oct 95
End Date: 30 Oct 95
Operaters: Rick Gillespie

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery Collected (gal)	LNAPL Recovery Total (gal)	LNAPL Recovery Rate (gph)	LNAPL Recovery Avg. Rate (gph)	Groundwater Recovery Collected (gal)	Groundwater Recovery Total (gal)	Groundwater Recovery Rate (gph)	Groundwater Recovery Avg. Rate (gph)
10-/28/95 1000	0	0.00	0.0	0.0	0.0	0.00	0.0	0.0	0.0
Daylight Savings 10/29/95 1056	25'52"	—	—			140.0	140.0		
10/30/95 0930	22'34"	1.64	1.64			115.0	255.0		
Total Time (hours)	48.5 0.00	Rate (gph)	#DIV/0!	Rate (gpd)	#DIV/0!	Rate (gph)	#DIV/0!	Rate (gpd)	#DIV/0!

Fuel and Water Recovery Data

Site: ~~Travis AFB~~ Hill AFB
Well ID: ~~Area G Wells~~ OU101
Test Type: Vacuum Enhancement

Start Date: 30 Oct 95
End Date: 3 Nov 95
Operaters: Rick Gillespie

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)	Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)
10-30-95/1230	0	0.00	0.0	0.0	0.0	0.00	80.4	0.0	0.0
2020	7'50	–	–			445	364.6		
10-31-95/0720	18'50	–	–			1050	605		
1300	24'30"	7.5	7.5			1274	224		
1810	29'40"	–	–			1571	297		
11-1-95/0743	43'13"	–	–			2083	512		
1230	47'58"	1.7	9.2			–	–		
2000	55'28"	–	–			2753	670		
11-2-95/0744	67'12"					3192	439		
1143	71'11"					3410	218		
1330	72'58"	1.4	10.6			–	–		
2000	79'28"	–	–			3768	358		
11-3-95/0735	91'03"	–	–			5177	1409		
0830	91'58"	1.5	12.1			5655	478		
Total Hrs	91'58"	Total:	12.1 gal			Total:	5574.6		
Total Time (hours)	0.00	Rate (gph)	#DIV/0!	Rate (gpd)	#DIV/0!	Rate (gph)	#DIV/0!	Rate (gpd)	#DIV/0!

Fuel and Water Recovery Data

Site: ~~Travis AFB~~ Hill AFB
Well ID: ~~Area G Wells~~ OW101
Test Type: ~~Vacuum Enhancement~~ Skimmer 24hr
Start Date: 3 Nov 95
End Date: 4 Nov 95
Operaters: Rick Gillespie

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)	Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)
11-3-95/0930	0	0.00	0.0	0.0	0.0	0.00	5655 ~~0.0~~	0.0	0.0
1440	7' 10"	–	–			5715	60		
2030	13'	–	–			5829	114		
11-4-95/0930	23' 30"	.6	.6			6059	230		
Total hrs=	24'	Total=	.6 gals			Total=	404 gals		
Total Time (hours)	0.00	Rate (gph)	#DIV/0!	Rate (gpd)	#DIV/0!	Rate (gph)	#DIV/0!	Rate (gpd)	#DIV/0!

Fuel and Water Recovery Data

Site:	~~Travis AFB~~ Hill AFB	Start Date:	4 Nov 95
Well ID:	~~Area G Wells~~ OU101	End Date:	6 Nov 95
Test Type:	~~Vacuum Enhancement~~ Drawdown 48hr	Operaters:	Rick Gillespie

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)	Collected (gal)	Total (gal)	Rate (gph)	Avg. Rate (gph)
4Nov95/0945	0	0.00	0.0	0.0	0.0	0.00	6059	0.0	0.0
1100	1' 15"	—	—			6303	244		
1325	3' 40"	—	—			6577	274		
1720	9' 35"	—	—			7054	477		
2120	11' 35"	—	—			7458	404		
5Nov95/0530	19' 45"	—	—			8381	923		
0930	23' 45	.3	6.3			8708	327		
1500	31' 15"	—	—			9298	590		
2000	36' 15"	—	—			9697	399		
6Nov95/0700	45' 15"					742.4	1045.4		
0845	47'	.7	1.0			807.6	65.2		
		Total:	1.0 gal			Total:	4748.6		
Total Time (hours)	0.00	Rate (gph)	#DIV/0!	Rate (gpd)	#DIV/0!	Rate (gph)	#DIV/0!	Rate (gpd)	#DIV/0!

Bioslurping Pilot Test
(Data Sheet 2)
Pilot Test Pumping Data

Page ___ of ___

Site: Hill AFB

Start Date: 28Oct95

Operators: R. Gillespie

Start Time: 1000

Test Type: Skimmer 48L

Well ID: OU101

Depth to Groundwater: 28.95' Depth to Fuel: 28.39'

Depth of Tube: 28.15'

Date/Time	Run Time	Vapor Extraction: Stack Pressure (in. H_2O)	Vapor Extraction: Carbon Drums (in. H_2O)	Vapor Extraction: Flowrate (scfm)	Pump Stack Temp (°C)	Pump Head Vacuum (in. Hg)	Extraction Well Vacuum (in. H_2O)
28Oct95/1010		.65	—		—	10.0	—
1410		.37	—		43.3	13.5	—
1730		.35	—		43.3	13.0	—
2100		.32	—		43.3	13.0	—
29Oct95/0530		.28	—		40.0	13.0	—
1041		.34	—		43.3	13.0	—
1915		.31	—		43.3	13.0	—
30Oct95/0630		.26	—		42.2	13.0	—
0900		.31	—		43.3	13.0	—

Figure 14. Typical Record Sheets for Bioslurper Pilot Testing (continued)

Bioslurping Pilot Test
(Data Sheet 2)
Pilot Test Pumping Data

Page ____ of ____

Site: Hill AFB

Operators: R. Gillespie / Greg Headington

Test Type: Vacuum-Enhanced

Depth to Groundwater: 28.79' Depth to Fuel: 28.735

Start Date: 30 Oct 95

Start Time: 1230

Well ID: OU101

Depth of Tube: ________

Date/Time	Run Time	Vapor Extraction: Stack Pressure (in. H_2O)	Vapor Extraction: Carbon Drums (in. H_2O)	Vapor Extraction: Flowrate (scfm)	Pump Stack Temp (°C)	Pump Head Vacuum (in. Hg)	Extraction Well Vacuum (in. H_2O)
30Oct95/1310		.17	—	22	32.2	18.0	
1540		.17	—	22	32.2	18.5	1.20
2020		.19	—	24	30.0	18.0	1.15
31Oct95/0720		.18	—	23	32.2	18.0	1.20
		.19	—	24	32.2	18.0	1.25
		.19	—	24	31.1	18.0	1.20
		.20	—	25	29.4	18.0	1.20
		.21	—	26	28.8	17.5	1.20
		.21	—	26	27.7	18.0	1.15
		.23	—	28	33.3	17.5	1.25
		.17	—	22	31.1	17.5	1.20
		.19	—	24	27.7	17.5	1.20

Figure 14. Typical Record Sheets for Bioslurper Pilot Testing (continued)

Bioslurping Pilot Test
(Data Sheet 2)
Pilot Test Pumping Data

Page ____ of ____

Site: Hill AFB

Start Date: 3Nov95

Operators: R. Gillespie / Greg Headington

Start Time: 0930

Test Type: Skimmer (24 hr)

Well ID: OU101

Depth to Groundwater: 28.825 Depth to Fuel: 28.82

Depth of Tube: 28.825

Date/Time	Run Time	Vapor Extraction: Stack Pressure (in. H_2O)	Vapor Extraction: Carbon Drums (in. H_2O)	Vapor Extraction: Flowrate (scfm)	Pump Stack Temp (°C)	Pump Head Vacuum (in. Hg)	Extraction Well Vacuum (in. H_2O)
3Nov95/0930		.35	—		25.5	16.0	—
1440		.37	—		40.0	15.0	.10
2030		.38	—		37.7	15.0	.10
4Nov95/0900		.37	—		36.6	15.5	.085

Figure 14. Typical Record Sheets for Bioslurper Pilot Testing (continued)

Bioslurping Pilot Test
(Data Sheet 2)
Pilot Test Pumping Data

Page ___ of ___

Site: Hill AFB

Operators: R. Gillespie

Test Type: Drawdown 48hr

Depth to Groundwater: ________ Depth to Fuel: ________

Start Date: 4 Nov 95

Start Time: 0945

Well ID: OU101

Depth of Tube: ________

Date/Time	Run Time	Vapor Extraction: Stack Pressure (in. H_2O)	Vapor Extraction: Carbon Drums (in. H_2O)	Vapor Extraction: Flowrate (scfm)	Pump Stack Temp (°C)	Pump Head Vacuum (in. Hg)	Extraction Well Vacuum (in. H_2O)
4Nov95/0945		.10	~~[illegible]~~	17	24.4	21.0	.015
1100		.06	—	10	23.3	21.0	.035
1325		.06	—	10	24.4	21.0	.04
1720		.06	—	10	21.1	20.0	.03
2110		.07	—	12	20.0	20.0	.04
5Nov95/0930		.09	—	16	25.5	20.0	.04
1500		.10	—	17	25.5	20.0	.05
2000		.10	—	17	24.4	19.5	.04
6Nov95/0715		.10	—	17	24.4	19.5	.04

Figure 14. Typical Record Sheets for Bioslurper Pilot Testing (continued)

APPENDIX E

SOIL GAS PERMEABILITY TEST RESULTS

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: 30 Oct95/1230
DISTANCE FROM VENT WELL (ft. & tenths)	10'	10'	10'		SITE: Hill AFB: OU101
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY: R. Gillespie / Greg Headington
	Green (8')	Blue (16')	Red (24')		COMMENTS
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	
0	0.035	0.19	—		* For the first 4 minutes
1	—	—	—		No readings were taken b/c
2	—	—	—		of a faulty magnehilic board.
3	—	—	—		(—) denotes no reading
4	—	—	—		
5	0.105	0.28	0.43		
6	0.11	0.29	0.45		
7	0.115	0.30	0.46		
8	0.12	0.30	0.46		
9	0.125	0.30	0.46		
10	0.125	0.30	0.46		
12	0.125	0.31	0.46		
14	0.130	0.32	0.46		
16	—	—	—		

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: 30 Oct 95 / 1230
DISTANCE FROM VENT WELL (ft. & tenths)	10'	10'	10'		SITE: Hill AFB: OU101
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY: L. Gillespie
	Green (8')	Blue (16')	Red (24')		COMMENTS
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	
18	—	—	—		
20	—	—	—		
24	0.125	0.31	0.46		
28	0.135	0.32	0.47		
32	—	—	—		
36	0.135	0.33	0.47		
40	0.125	0.32	0.47		

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: 30 Oct 95 / 1230
DISTANCE FROM VENT WELL (ft. & tenths)	30'	30'	30'		SITE: Hill AFB : OU101
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY: R. Gillespie
	Green (8')	Blue (16')	Red (24')		COMMENTS
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	
0	0	0	0.06		
1	0.015	0.14	0.21		
2	0.04	0.18	0.25		
3	0.08	0.19	0.25		
4	0.065	0.215	0.27		
5	0.085	0.22	0.27		
6	0.09	0.23	0.29		
7	0.09	0.235	0.30		
8	0.09	0.235	0.30		
9	0.09	0.235	0.30		
10	0.10	0.235	0.30		
12	0.095	0.24	0.31		
14	0.09	0.24	0.30		
16	0.095	0.24	0.30		

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: 30Oct95/1230
DISTANCE FROM VENT WELL (ft. & tenths)	30'	30'	30'		SITE: Hill AFB: OU101
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY: R. Gillespie
	Green (8')	Blue (16')	Red (24')		
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	COMMENTS
18	—	—	—		
20	.09	0.235	.30		
24	.09	.235	.30		
28	.095	.24	.30		
32	.09	.235	.30		
36	.09	.235	.30		
40	.085	.235	.29		

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: 30 Oct 95 / 1230
DISTANCE FROM VENT WELL (ft. & tenths)	48'	48'	48'		SITE: Hill AFB: OU101
TIME FROM START-UP (MIN.)	PT. CODE	PT. CODE	PT. CODE	PT. CODE	RECORDED BY: R. Gillespie / W. Ziebenlist
	Green (8')	Blue (16')	Red (24')		
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	COMMENTS
0	0.0	0.0	0.0		
1	0.01	.1	0.12		
2	.04	0.13	0.15		
3	.05	0.14	.155		
4	.06	0.16	.17		
5	.07	.17	.18		
6	.07	.18	.195		
7	.085	.19	.20		
8	.09	.19	.205		
9	.09	.19	.20		
10	.085	.185	.20		
12	.09	.19	.21		
14	.09	.195	.21		
16	.095	.195	.21		

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST				DATE/TIME: 30 Oct95/1230
DISTANCE FROM VENT WELL (ft. & tenths)	48'	48'	48'		SITE: Hill AFB: OU101
TIME FROM START-UP (MIN.)	PT. CODE Green (8')	PT. CODE Blue ([illegible])	PT. CODE Red (24)'	PT. CODE	RECORDED BY: R. Gillespie
	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	PRESSURE (IN H_2O)	COMMENTS
18	.095	.195	.215		
20	—	—	—		
24	.09	.19	.205		
28	.09	.195	.215		
32	.09	.195	.21		
36	.1	.20	.22		
40	.09	.19	.205		

APPENDIX F

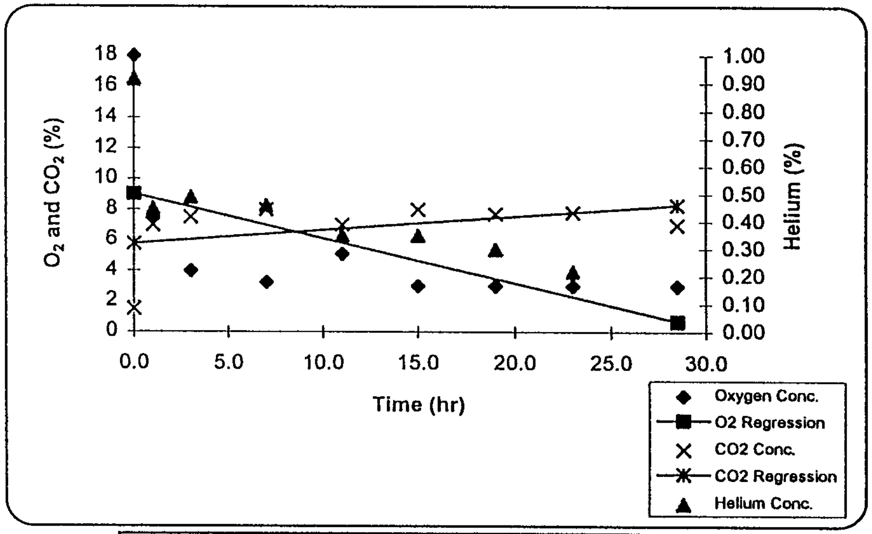
IN SITU RESPIRATION TEST RESULTS

In Situ Respiration Test

Date: 12/13/95 | Site Name: Hill AFB, UT

Monitoring Point: OU101-10-Red | Depth of M.P. (ft): 24

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
11/4/95 10:30	0.0	18.00	1.50	0.92
11/4/95 11:30	1.0	7.50	7.00	0.45
11/4/95 13:30	3.0	4.00	7.50	0.49
11/4/95 17:30	7.0	3.25	8.00	0.46
11/4/95 21:30	11.0	5.10	7.00	0.35
11/5/95 1:30	15.0	3.00	8.00	0.35
11/5/95 5:30	19.0	3.00	7.70	0.30
11/5/95 9:30	23.0	3.00	7.80	0.22
11/5/95 15:00	28.5	3.00	7.00	



O_2 Utilization Rate

Ko 0.005 %/min
0.292 %/hr
7.014 %/day

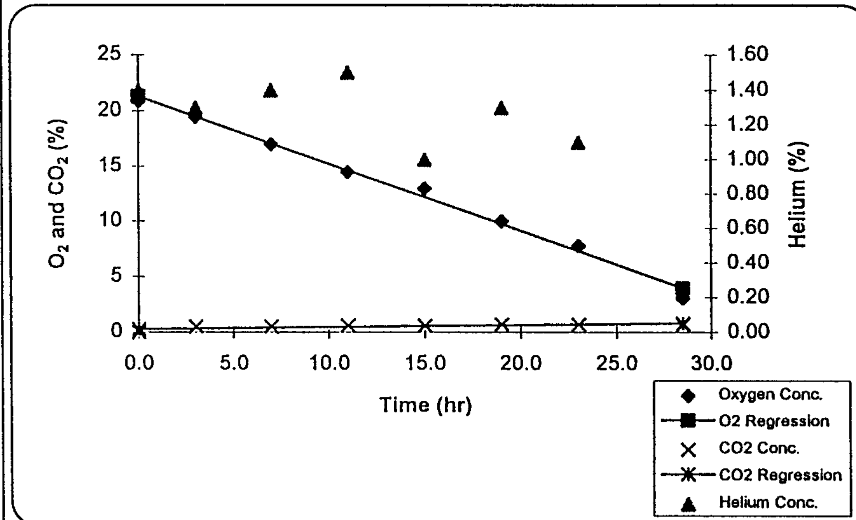
Regression Lines	O_2	CO_2
Slope	-0.2922	0.0888
Intercept	9.0296	5.7725
Determination Coef.	0.3648	0.1945
No. of Data Points.	9	9

In Situ Respiration Test

Date: 12/14/95 Site Name: Hill AFB, UT

Monitoring Point: OU101-10-Green Depth of M.P. (ft): 8

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
11/4/95 10:30	0.0	20.90	0.00	1.40
11/4/95 13:30	3.0	19.50	0.50	1.30
11/4/95 17:30	7.0	17.00	0.50	1.40
11/4/95 21:30	11.0	14.50	0.60	1.50
11/5/95 1:30	15.0	13.00	0.60	1.00
11/5/95 5:30	19.0	10.00	0.70	1.30
11/5/95 9:30	23.0	7.80	0.70	1.10
11/5/95 15:00	28.5	3.10	0.70	



O_2 Utilization Rate

Ko 0.010 %/min
0.608 %/hr
14.596 %/day

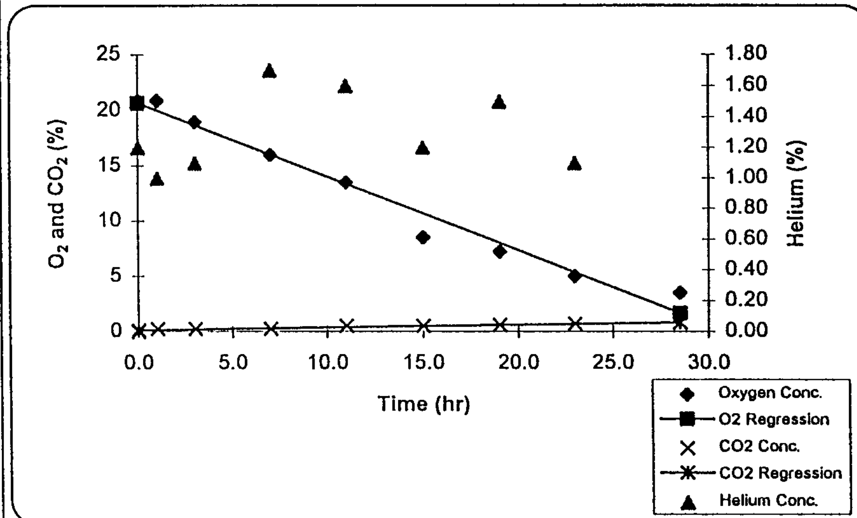
Regression Lines	O_2	CO_2
Slope	-0.6082	0.0185
Intercept	21.3214	0.2918
Determination Coef.	0.9926	0.6192
No. of Data Points.	8	8

In Situ Respiration Test

Date: 12/14/95 **Site Name:** Hill AFB, UT

Monitoring Point: OU101-30-Green **Depth of M.P. (ft):** 8

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
11/4/95 10:30	0.0	20.90	0.00	1.20
11/4/95 11:30	1.0	20.90	0.25	1.00
11/4/95 13:30	3.0	19.00	0.25	1.10
11/4/95 17:30	7.0	16.00	0.25	1.70
11/4/95 21:30	11.0	13.50	0.50	1.60
11/5/95 1:30	15.0	8.50	0.50	1.20
11/5/95 5:30	19.0	7.20	0.60	1.50
11/5/95 9:30	23.0	5.00	0.70	1.10
11/5/95 15:00	28.5	3.50	0.80	



O_2 Utilization Rate

Ko 0.011 %/min
0.668 %/hr
16.040 %/day

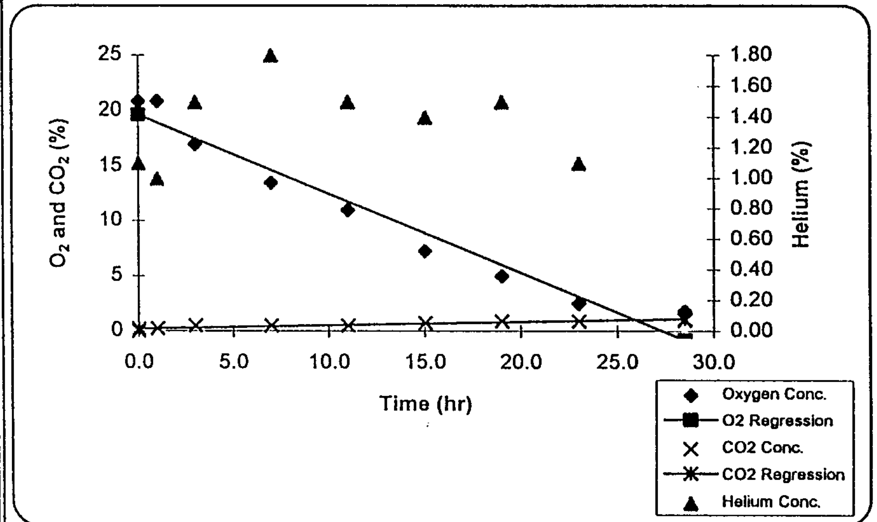
Regression Lines	O_2	CO_2
Slope	-0.6683	0.0244
Intercept	20.7051	0.1367
Determination Coef.	0.9740	0.9217
No. of Data Points.	9	9

In Situ Respiration Test

Date: 12/14/95 | Site Name: Hill AFB, UT

Monitoring Point: OU101-48-Green | Depth of M.P. (ft): 8

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
11/4/95 10:30	0.0	20.90	0.00	1.10
11/4/95 11:30	1.0	20.90	0.25	1.00
11/4/95 13:30	3.0	17.00	0.50	1.50
11/4/95 17:30	7.0	13.50	0.50	1.80
11/4/95 21:30	11.0	11.00	0.50	1.50
11/5/95 1:30	15.0	7.25	0.75	1.40
11/5/95 5:30	19.0	5.00	0.90	1.50
11/5/95 9:30	23.0	2.50	0.90	1.10
11/5/95 15:00	28.5	1.80	1.00	



O_2 Utilization Rate

Ko	0.012	%/min
	0.720	%/hr
	17.279	%/day

Regression Lines	O_2	CO_2
Slope	-0.7200	0.0304
Intercept	19.6942	0.2262
Determination Coef.	0.9586	0.8684
No. of Data Points.	9	9